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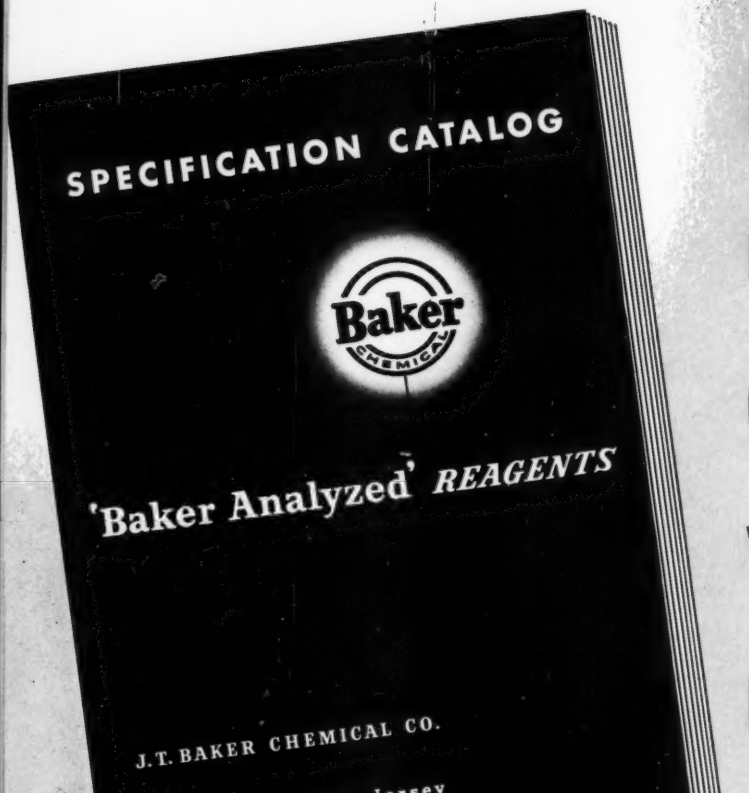

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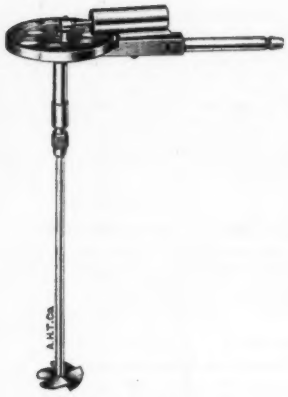

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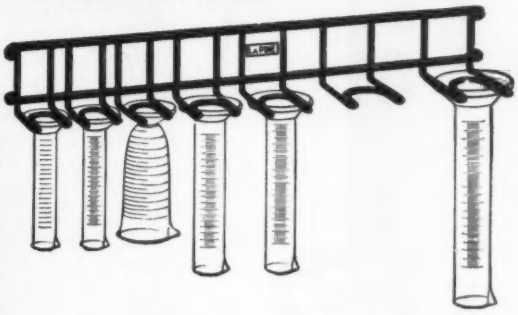

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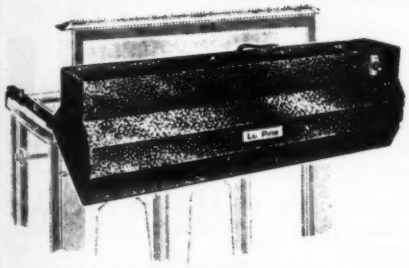

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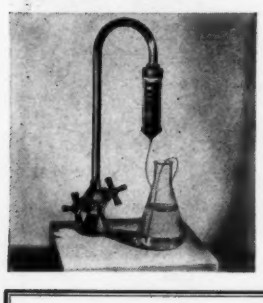

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MAXIMUM POWER CONSUMPTION 850 watts. Dimensions: Outside, 16" x 11¾" x 11⅞". Inside 9" x 11¼" x 11¼".

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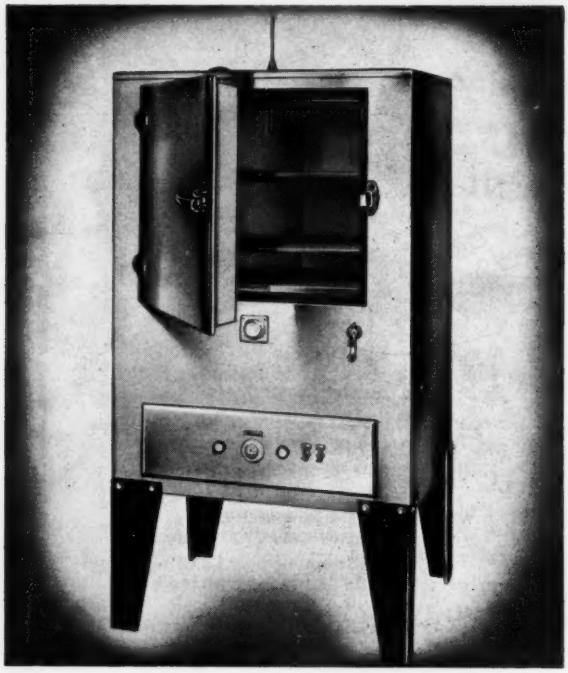

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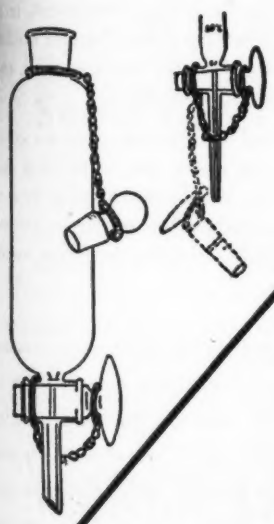
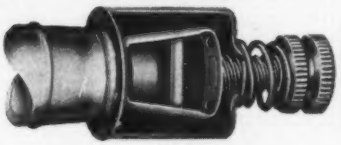


This Single Size Adapter converts ANY glass stopcock ***to pressure-tight stopcock!***



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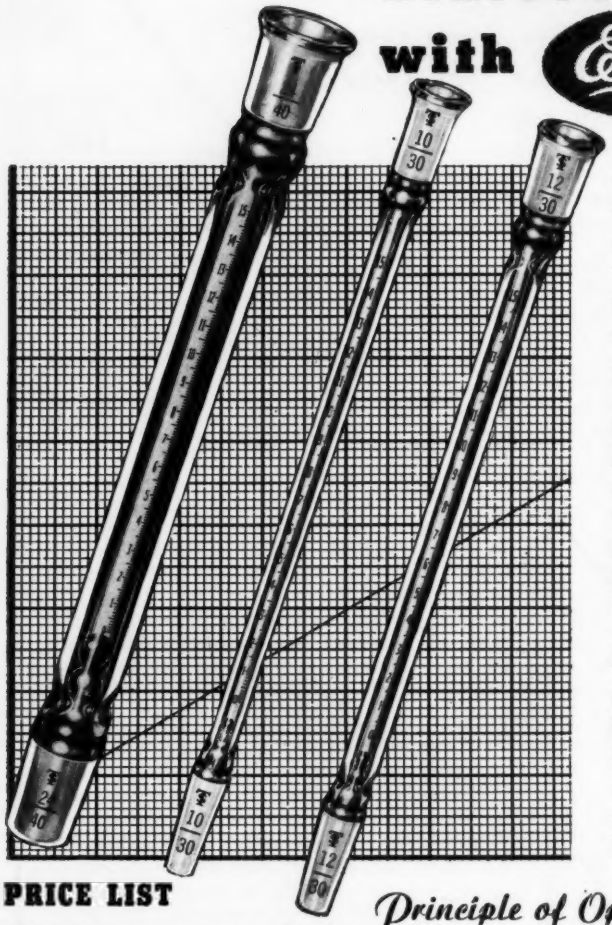

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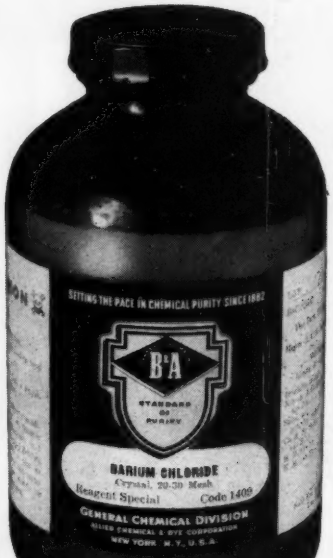

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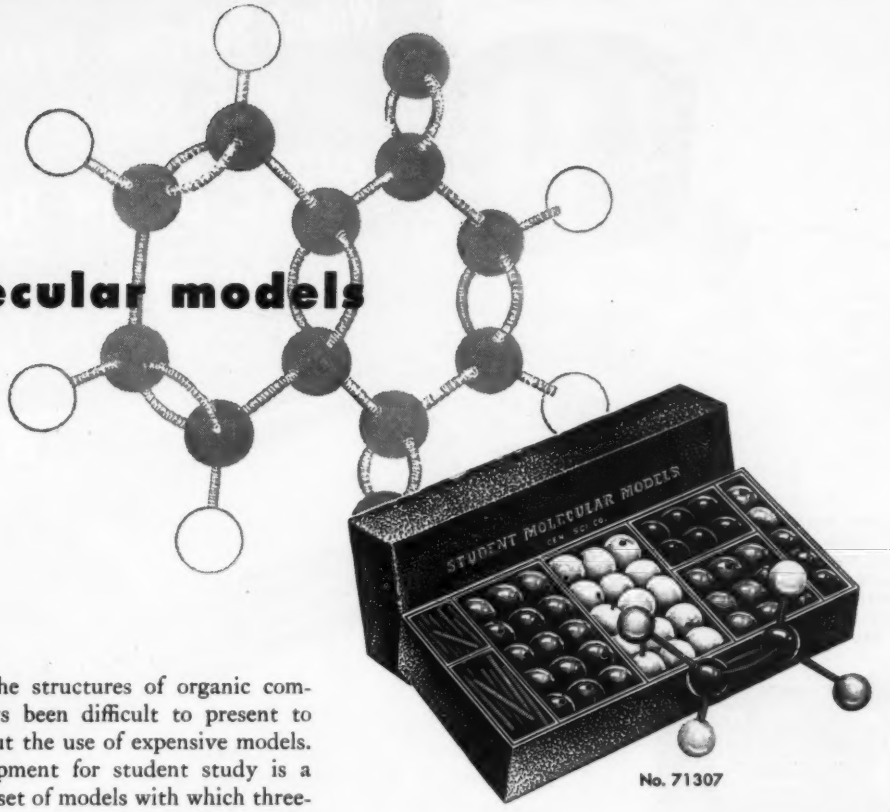

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The set was developed according to the suggestions of Professor George F. Wright and other members of the department of chemistry of the University of Toronto. Colored wood balls represent atoms; ⅛″ diameter coil springs represent multiple and cyclic valence bonds. Four holes, drilled at angles of 119° 28′ in the black carbon balls, allow formation of the tetrahedron postulated by van't Hoff and LeBel; this arrangement permits showing diastereoisomerism and enantiomerism of substances such as lactic and tartaric acid.

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The colored balls, ¾″ in diameter, include: 30 Carbon (black); 30 Hydrogen (white); 12 Oxygen (red); 18 Halogens (green); 5 Nitrogen (orange); 5 Sulfur (yellow). The diameter of the holes permits use of cut household matches for rigid bonds in permanent models.

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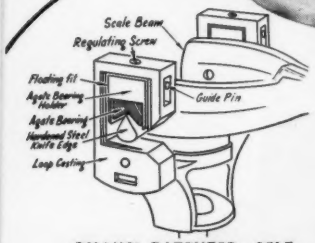

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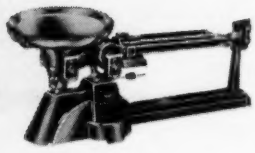

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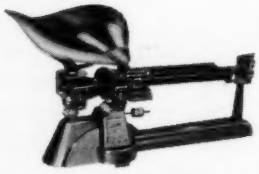
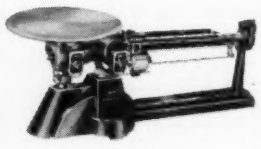
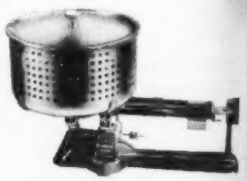


Model 720: Balance with 11" x 5½" x 3" deep brass scoop. Particularly useful for weighing powders, grain, food products, small parts, etc.



Model 760: Balance with tare beam and poise. Saves deducting weight of container when determining net weight values. Tare capacity 250 grams.



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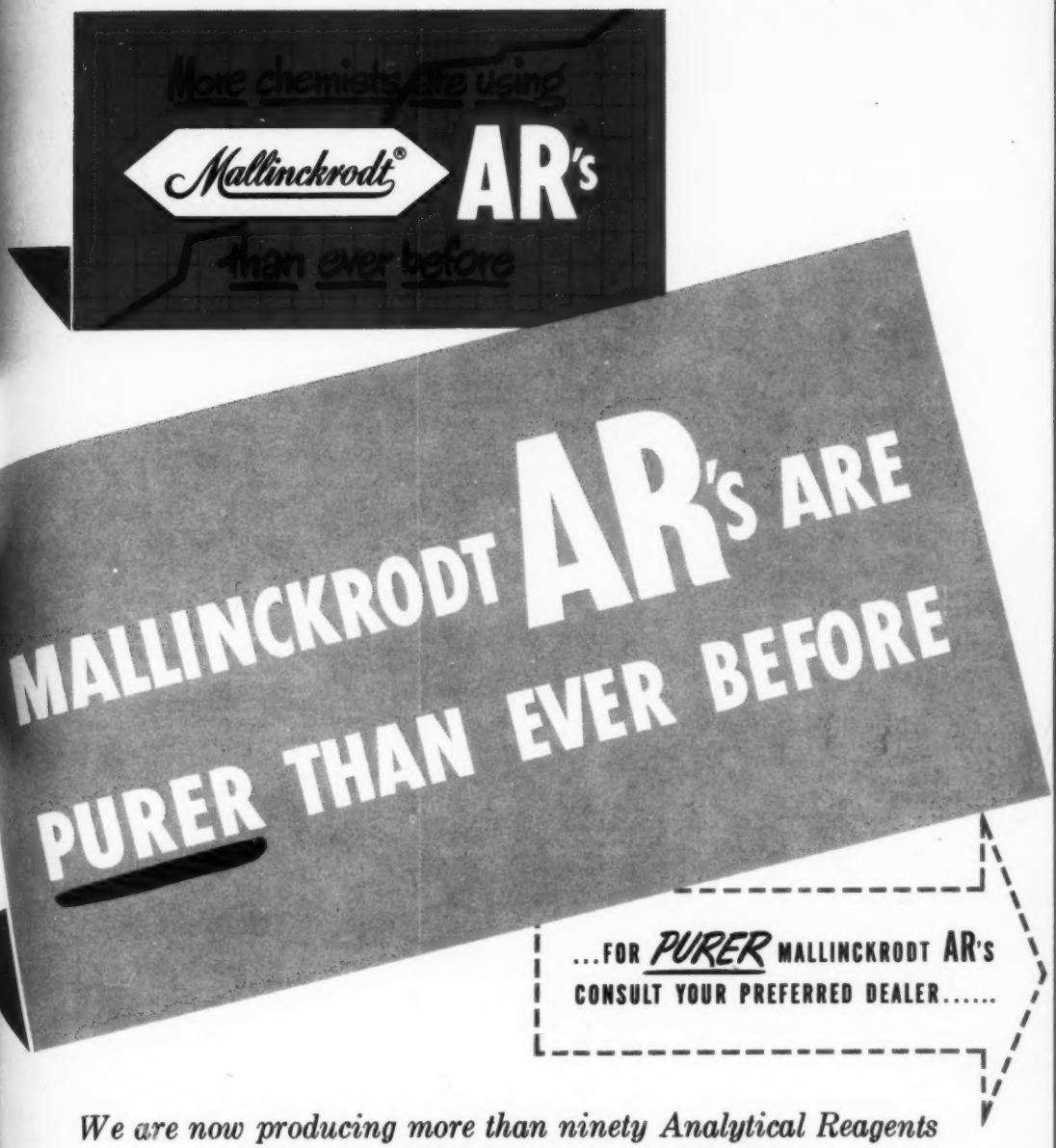

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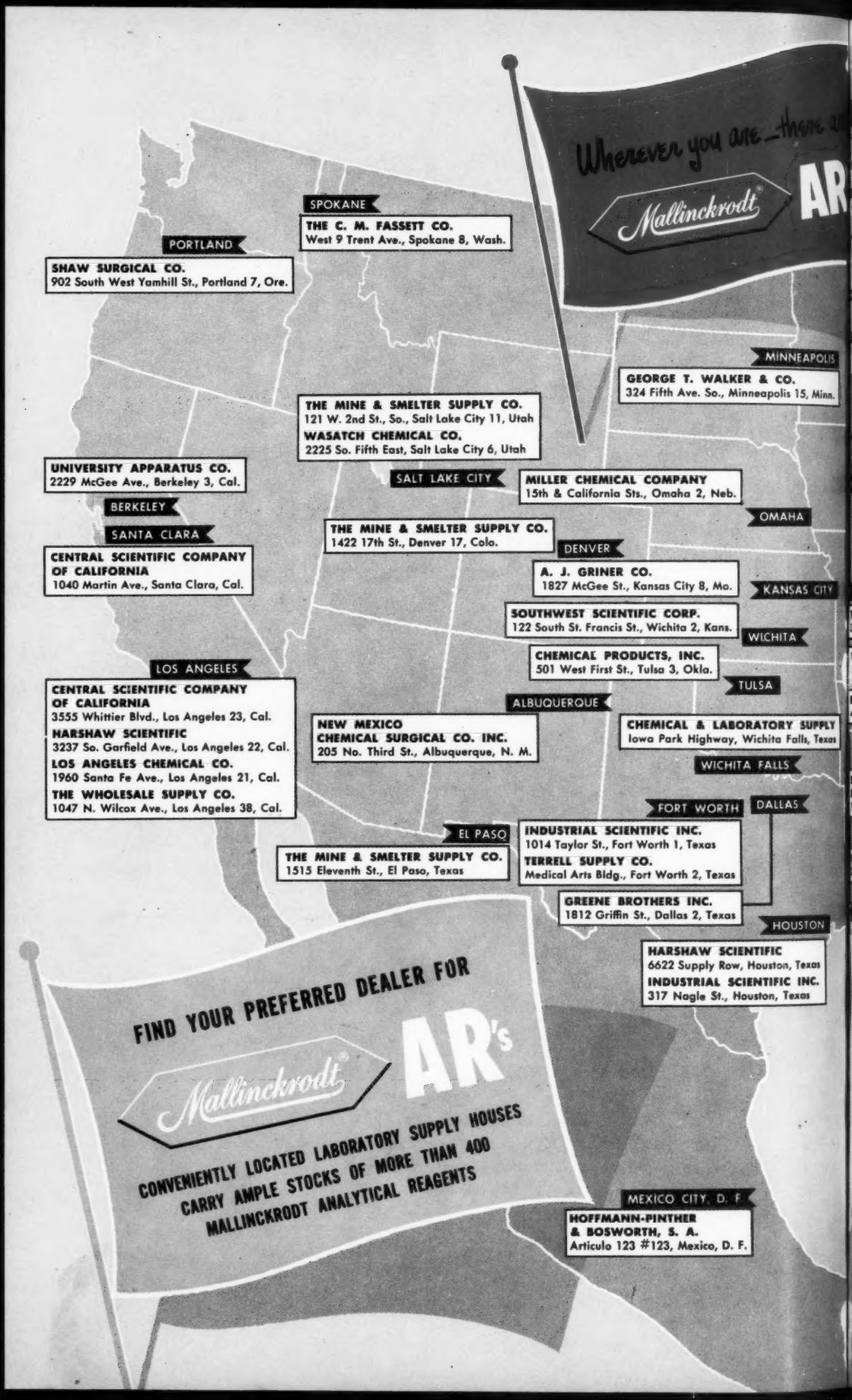
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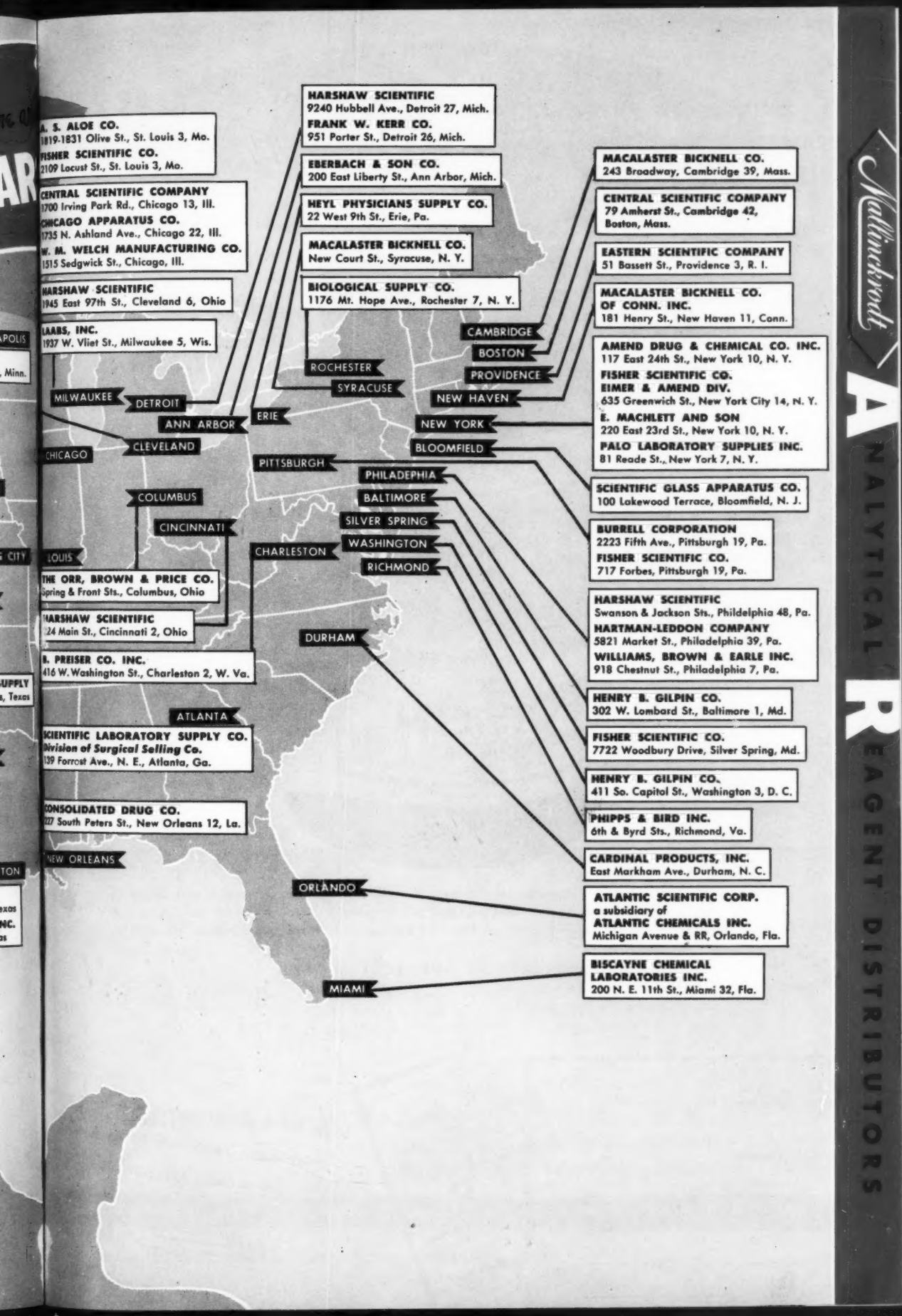
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(See page 538)

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Editor's Outlook

WE QUOTE the following pertinent comment from *The Chemical Age* (August 11, 1951):

Sir Cyril Hinshelwood's presidential address to the chemical section of the British Association... contained, as we have come to expect from this outstanding man, far more than is confined within the technical limits of the subject of chemistry. Chemistry in its wider form links us with the processes of life itself, and poses problems as difficult as any to solve. The problems have been with us ever since the Chinese invented gunpowder, but they more urgently need solving today because not to solve them threatens annihilation. Sir Cyril embarked on the controversial question of responsibility for this state of affairs. Rightly he points out that scientists cannot be blamed if their search for truth is prostituted by the layman and used by him for purposes of destruction. Every advance in any kind of knowledge brings an equivalent power for good or for evil with it, and which it is to be is governed solely by the people who use it, not the people who discover it. This probably brings cold comfort to the ordinary mortal, who neither discovers nor uses it, but sits in a kind of scientific no-man's-land waiting for the first hydrogen bomb to be dropped and the first whiff of the latest nerve-paralysing gas to be pumped down to him. He, like the defiant pedestrian who was just as dead as if he had been in the wrong, is not likely to care very much who is responsible if the time ever does come. Nevertheless, it is not the search for truth that brings these evils into the world, but the search for power.

This situation offers a special problem to scientists. Having brought knowledge into the world they not unnaturally seek to influence the people who are going to use it. The difficulty with this, however, is that the mind that is primarily interested in knowledge and the search for truth is, by virtue of its own training, often different to the mind that has to deal with inexact, biologically variable and frequently inconsistent human beings. There is no scientific approach to compromise, and scientists sometimes forget that persuading a number of human beings to go the same way is not at all the same thing as manipulating reactions in a laboratory. When it comes to human problems they are unfortunately no better qualified than anyone else untrained in the subject, and when it comes to dealing with the power politicians that are the scourges of this age, their limitations often become even more apparent.

FRANÇOIS DESCROIZILLES, THE INVENTOR OF VOLUMETRIC ANALYSIS

CLÉMENT DUVAL
The Sorbonne, Paris, France
(*Translated by Ralph E. Oesper*)

THIS paper gives a short account of the life and accomplishments of a French chemist, pharmacist, and inventor, who ranks among the most deserving and also the most disregarded. All of his discoveries have been taken over by others. He died in straitened circumstances even though he made the industrial fortune of an entire region. He is indubitably the inventor of volumetric analysis. In all his efforts he was actuated by a single ideal: "to advance science and to make himself useful to his fellow-countrymen."

François Antoine Henri Descroizilles was born at Dieppe on Friday, June 11, 1751, and hence the bicentenary of his birth seems a fitting time for one of his compatriots to remind the chemical world of the debt it owes to this talented early chemist.

Many of the circumstances of his life resulted from the fact that he was born in one of the largest ports in the French kingdom, situated near another big city, which adjoined a fertile countryside where a famous cider was produced. It must not be forgotten that he came from a line of not less than five generations of apothecaries, spicers, and chandlers, because in those times the business was passed down from father to son; each of these generations of his ancestors over the span of a hundred years contributed to making François Antoine Henri what he was.

Normandy has given the world many eminent chemists. Everyone knows the achievements of Vauquelin, Nicolas Lémery, Rouelle the younger (the teacher of Lavoisier), Édouard Adam, Dulong, Grignard, Delépine, to cite only the most notable.

Known from Roman times, the port of Dieppe has passed into history. It was there that the earliest hydrographic maps were made; it was the port of departure of the boldest navigators: Cousin, who perhaps discovered America four years before Columbus; Parmentier, who voyaged to Brazil, Canada, and Sumatra; Chauvin, who sailed to Canada; Guillaume de Caen to Newfoundland; Jean Ribault to Florida; Diel d'Esnambouc to St. Christopher. It was a Dieppois, namely, Captain de Clieu, who brought the first two coffee trees to Martinique. These trees were carefully guarded until the terrible eruption of Mt. Pelée in 1902. Dieppe grew wealthy from the trade in furs, gold, spices, ivory, and drugs. The Revocation of the Edict of Nantes (1685) dealt a hard blow to this commerce because much of the city's population was Protestant. The terrific bombardment by the English in 1694 reduced the city almost to ashes. At present, the city is slowly emerging from the shell of reinforced concrete in which it was clothed during World War II; it still vibrates with the heroism of the brave Canadians, who trod its soil for several hours before the "true liberation."

THE DESCROIZILLES FAMILY

Philippe, first of the name (to our knowledge), took the apothecary's oath at Dieppe on September 22, 1639; his signature appears on minutes of the meetings of the corporation, and he showed great zeal in defending its interests. The local history notes his devotion to his fellow citizens during the great famine of 1661 and the epidemic of the plague in 1668. His son Philippe appears to have succeeded him after this same date and to have kept the pharmacy until April 16, 1692, after having been named *Garde ancien* in 1686. As a Catholic, he opposed the entrance of Protestants into the pharmaceutical profession, particularly after the Revocation.

The reign of Philippe Descroizilles III was marked by the restoration of the ruins of the house destroyed in the bombardment of 1694, and by the campaign (1710–15) against the vinegar makers, who tried to prevent the apothecaries from selling products derived from vinegar. His son, Philippe IV, in 1743 relinquished the pharmacy to his brother François, the father of our François Antoine Henri.

François Descroizilles, the father, was born at Dieppe on September 20, 1707, and studied at Paris under Geoffroy and Bernard de Jussieu. He showed a definite taste for botany. On April 29, 1749, *i. e.*, at the age of 42, he married Mlle. Reyne Niel, by whom he had 16 children; 11 girls and 5 boys. In 1744 he was elected *associé adjoint* of the Académie des Sciences, Arts et Belles Lettres of Rouen, to which he made a report on a loggerhead turtle which was stranded at Dieppe in 1752. Again, in 1774, he reported "an attempt to correct and sweeten tart wines." All his life he fought against the drug peddlers. He invented a *polychrest salt* (a mixture of magnesium sulfate, sodium chloride, and sodium sulfate) which was designed to function as a laxative, dissolvent, and sedative. This preparation had some success as late as 1820. An advertisement for this remedy and a brochure setting forth its benefits, especially among constipated women, have been preserved. In style it does not differ much from certain

modern medical prospectuses. "My only aim in writing this work is the welfare of humanity; my desire is to relieve those whose condition and indulgence have exposed them to the need of help in their prolonged and painful infirmities." He died on March 13, 1783, and Reyne Niel, his widow, wrote on the last page of the *livre de raison* (genealogy book): "I have had the misfortune to lose my worthy and respectable husband."

Nine of the children of François and Reyne died at an early age, doubtless while out at nurse in the environs of Dieppe. Two of the daughters married apothecaries, a third became a curate's wife. Among the five sons, it is necessary to make special mention of Jean Hyacinthe Alexandre (born March 24, 1761) a capable botanist, who successfully cultivated camomile (*Anthemis nobilis*) on the coast of Janval (near Dieppe); he popularized the growing of potatoes in this corner of France, and started an isinglass factory at Dieppe. The Académie of Rouen has preserved his paper: "Stalk of the *Angelica sativa* proposed as a replacement for tea."

Another brother, Jacques Frederic (born April 13, 1765), was associated with the great chemist at the Lescure-les-Rouen plant. He then emigrated to the Ile de France and finally to Reunion, where he became a planter. His pamphlet on the agriculture of these colonies is preserved in the municipal library of Rouen.

What documents have been preserved concerning Descroizilles and his family? In his "Leçons de Chimie élémentaire appliquée aux Arts industriels" (5th ed., Paris, 1877), M. J. Girardin, professor in the Faculté de Pharmacie of Lille, noted the need of a review of the scientific accomplishments of this gifted inventor, and charged Paul Descroizilles to assemble all his father's writings; he died before he could finish the task, and his sister Caroline turned over the documents she possessed to De Lérue, a member of the Rouen Académie, who at once published a "Notice sur Descroizilles, chimiste, né à Dieppe, et sur les membres de sa famille." In his "Étude sur la corporation des Apothicaires de Rouen aux XVII et XVIII e siècles" (Rouen, 1902), A. Poussier devoted pages 16 to 19 to Descroizilles, of whom he also speaks at greater length in his "De l'origine du blanchiment du coton à Rouen" (Rouen, 1924), a pamphlet of 10 pages containing the portrait which accompanies the present paper. The principal work on Descroizilles is the doctoral thesis in pharmacy at Lille, submitted June 27, 1921, by the pharmacist Louis Constant Victor Simon (Rouen, 1921). Most of the better material contained in this paper was gleaned from these sources and from documents collected while the writer[1] was professor at the École des Sciences at Rouen from 1935 to 1943.

EARLY YEARS

On January 30, 1847, Sellier, the mayor of Dieppe, ordered a marble tablet to be placed on the front of the house at No. 17 Place Royale, birthplace of the Descroizilles, father and son. This plaque still exists, and it confirms the birthdate. The register of the parish of St. Jacques of Dieppe for 1751 records that the child was baptized the following day.[2]

The boy received his schooling in the humanities at the College of Dieppe conducted by the learned Oratorians, who had been established in this city since 1614. He was particularly attracted to Latin and botany. He botanized with his father on the cliffs and the shore; he was interested in the laboratory equipment and preparations. After some sort of a course in pharmacy, his father sent him to Paris, where he studied in the laboratory of Rouelle the Younger and in that of Thenard.

Tablet on the Birthplace of Descroizilles, 17 Place Royale, Dieppe

In 1777, when he was 26, Descroizilles returned to Rouen with the certificate *demonstrateur royal de chymie* and he obtained from the King (Louis XVI) a license of apprenticeship, issued at Versailles on January 14, 1778, permitting him to establish himself in a large city if he passed the apothecary examination. During this interval he was chosen as expert by the Parliament in the trials brought against adulterators of cider. On this occasion, he had to bring in well-grounded proofs with the result that he incurred the enmity of the official Rouen expert, the apothecary François Mésaize, whom he dared to contradict, contrary to established custom. Since the latter was the official representative of the king, Descroizilles was judged guilty of an affront to the sovereign himself.

[1] OESPER, R. E., J. CHEM. EDUC., **28**, 36 (1951).

[2] "Le samedi, douzième jour de juin a été baptisé par moy prestre, second vicaire soussigné, François, Antoine, Henri, né de hier du légitime mariage de Monsieur François Descroisilles, premier juge consul des marchands de cette ville et marchand apotiquaire, et de damoiselle Marie, Reine Niel son épouse de cette paroisse; le parain Monsieur Pierre Antoine François Niel, marchand de cette ville, la maraine, damoiselle Marie Catherine Descroisilles épouse du sieur Niel aussi marchand, tous deux de la paroisse de St Rémy, le père absent.

Signé Descroizilles, femme Niel
Niel
J. J. Gaillard, sous-vicaire."

(Copied from the archives of the Palais de Justice of Dieppe; the underlined words appear thus in the original.)

THE AFFAIR OF THE CIDERS

On April 27, 1775 the Parliament passed a decree stating: "under penalty of 500 francs fine and corporal punishment it is forbidden to add lead to ciders offered for public consumption." Descroizilles found that he could detect lead in suspected ciders by means of liver of sulfur. He published this finding in the *Archives de Normandie* and later it appeared in a report from the hand of Descroizilles, read at Paris by Lavoisier to the Académie des Sciences (June 18, 1787), in the name of a Commission composed of Cadet, Baumé, Darcet, Berthollet, Descroizilles, countersigned by Condorcet.

Descroizilles was "condemned to a fine of 3 francs against the King and forbidden to repeat the offense under threat of greater punishment," but he appealed. Some experiments made in Paris (Hôtel des Ternes, at the home of Baumé) finally showed that Descroizilles was correct, and he was not only cleared of the charge but thanked for his zeal in behalf of the public welfare.[3]

All Normandy was interested in this matter concerning the addition of lead to cider, where it acted as a clarifying agent. The situation was so acute that at cider-making time the priests were ordered to announce the penalties (including death) to which the adulterators were subject. From the chemical point of view Descroizilles made a study of the black lead sulfide and showed that the addition of chalk did not interfere with this test.

He was interested in cider all his life; it led him to construct a still and a tube for determining alcohol. Toward the end of his career he studied the desiccation of apples. In a letter sent (1825) to his brother Jean Hyacinthe Alexandre, the botanist, he stated:

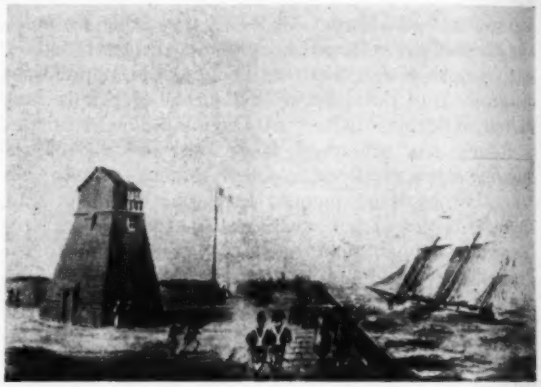
> I have been very busy at Paris and Clichy (then a small village north of Paris) where I go to dine and lodge almost every day. There, I spend my free time with some experiments on wine making. I am going to get an apple mill from Rouen. I am also setting up here a plant for drying apples in which it will be possible to dry large quantities very quickly, with great economy of space, fuel and labor. Their desiccation will be perfect. They may be stored well in a small space for several years, and can be shipped if desired to the East Indies. They produce at any time, and easily, a very palatable and healthy beverage, and can become of advantage to the health of sailors, and give rise to a large business . . . .[4]

[3] The Court of the Parliament of Rouen, on July 12, 1785, handed down the following ruling:

"Louis, par la Grâce de Dieu, Roi de France et de Navarre: A tous ceux qui ces présentes Lettres verront; Salut, savoir faisons, que ce jourd'hui, la cause offrante en notre Cour de Parlement de Rouen entre le Sieur François-Antoine-Henri Descroizilles, notre démonstrateur de Chymie à Rouen . . . . Notre dite cour a accordé et accorde mandement audit Descroizilles aux fins de sa requeste; ordonne qu'il sera sursis à l'execution de la sentence de la Police de Rouen du premier de ce mois . . . . Notre Premier Avocat Général, pour notre Procureur Général, lequel a dit: Qu'il s'en fallait beaucoup que la conduite du sieur Descroizilles, notre démonstrateur en Chymie, et la manière dont il s'est exprimé dans la Feuille qui lui attire la comdamnation flétrissante dont il se plaint, lui aient paru repréhensibles, que l'une et l'autre, au contraire, lui ont semblé dignes de louanges; que'elles sont le fruit de son amour pour le bien public et des utiles travaux dont nous lui avons confié l'exercice, et que notre premier avocat général croit devoir lue attirer la reconnaissance des gens de l'Art et la confiance de notre province; qu'il a donné son opinion en homme sage et instruit et qu'il en résulte pour l'utilité de la matière qu'il a savamment traitée, des lumières précieuses qui doivent servir à l'éclairer par la suite sur la conduite a tenir dans des circonstances qui peuvent se représenter . . . ."

THE FLASHING LIGHTHOUSES

Noël de la Morinière, classmate of Descroizilles, in his "Essai sur le Département de la Seine Inférieure," states that at this period the only harbor light at Dieppe was a single tallow candle, which had to be trimmed, which went out frequently, which was lighted only from



The Flashing Lighthouse at Dieppe (le phase à éclipse)

Michaelmas (September 29) to Easter, and which was easily confused with the lights from the houses surrounding the harbor.

In 1783 Descroizilles and the mayor of Dieppe, Lemoyne, his relative, were returning from Versailles, where they had gone to try to secure some improvements on the harbor. The wind moved the branches of the trees lining an avenue and thus at times eclipsed the light from the street oil lamps. According to his cousin Féret this gave Descroizilles the idea of a flashing lighthouse. The number of revolutions in a given period would indicate to the ship where it was.

A clockmaker of Dieppe, named Mulot or Mulotin, constructed the mechanism. The first wooden lighthouse was operating at the end of the main jetty in May, 1787.

> This light is in the form of a clock and the wheelwork causes a mass of light composed of 24 reflectors to alternately appear and disappear. It lasts 3 seconds and disappears for 1, and so on alternately. In this way, the seamen, informed of this mechanism, with watch in hand, can have no doubt that this is actually the point where they wish to touch land . . . .

Descroizilles never received any return from this invention, which is now in use all over the globe; more-

[4] The writer's father and grandfather did not have a cider press. In Normandy he has always seen them make their cider by the "méthode à l'alambic," which dates from Descroizilles, in contrast to the "méthode au pressoir" reserved for the well-to-do.

over his right to it was contested, the honor and profits going to others.

This lighthouse burned down and was replaced by a stone structure, which has also disappeared. It is described in "Notice sur Dieppe, Arques et quelques monuments circonvoisins" by Féret (Dieppe, 1824) and in "A sketch of the History of Dieppe dedicated to his 1832 R. A. the Duke of Orleans by an English Gentleman," who wrote: "The origin of this ingenious invention is due to Mr. Descroizilles and the mechanical part executed by Mr. Mulotin, both of them natives of that place...."

THE COFFEE-MAKER

Previously,

"...cette liqueur si chère
Qui manquait à Virgile et qu'adorait Voltaire..."

had been prepared *"à la sultane," i. e.*, by pouring boiling water on ground coffee placed at the bottom of a cloth bag. All the aroma went into the room; which was why this same Voltaire was led to declare that "he was drinking coffee *à gorge deployée.*" One day, at Lescure-les-Rouen, Descroizilles entertained Chaptal and Fourcroy, who were delighted at the quality of the coffee served. Their host then showed them an apparatus he had invented. This *cafeolette*, consisting of a cylinder with holes in its base, was charged with ground coffee, which was then covered with a perforated disc, and boiling water was poured in. The infusion was collected in the lower cylinder which fitted on the upper piece. This was the first known dripolator. An identical apparatus will be discussed later under the name *couloire* (colander). Descroizilles had some of his drip coffeepots constructed by a tinsmith on the rue Damiette in Rouen as presents for his guests. This artisan seized on the idea which had not been patented; he set up a business in Paris and rapidly amassed a fortune there with the help of the Abbé du Belloy, who advertised the superiority of the apparatus at the court. Consequently the unpretentious coffee-maker devised by Descroizilles, which is now used everywhere, became known under the high-sounding title *alambic à la Du Belloy*. On the other hand, Chaptal spread the fame of the apparatus in the Flemish countries and in Artois, where it is still called the *chaptal*.

DESCROIZILLES, THE APOTHECARY

Poussier states that up to 1508, the apothecaries and spice sellers of Rouen were subject to the statutes and ordinances of all the corporations of apothecaries of the kingdom that had been drawn up by Philip the Fair, John the Good, and Charles VIII. Louis XII granted them separate statutes assigning to both certain rights and obligations. Their elected representatives were known as *gardes de la communauté*. Among the duties of the *syndic* and the *gardes* was the examination of the sons of the masters; they oversaw the execution of the laws and ordinances governing the privileges of the profession; they had to inspect the pharmacies of the apothecaries and the shops of the spicers and chandlers several times a year; and they were expected to adjust equitably the various taxes levied by the corporation on its members, certainly an unenviable duty.

When Descroizilles returned to Rouen early in 1787 he offered a public course in chemistry, and also published various papers in the *Archives de Normandie*. As his earnings were small, he decided to obtain his master's certificate and then to conduct a pharmacy on the Rue de la Grosse Horloge in Rouen, as successor to Le Danoys. The latter had conducted a famous pharmacy there in a seventeenth-century house, which still stands, and had sold the best theriac there. This preparation contained no fewer than 72 ingredients, including opium, and was employed as a remedy for stomach pains.

The examinations were held only twice a year, on Quasimodo (first Sunday after Easter) and on All Saints Day (November 1). Descroizilles therefore addressed a *lettre expositive* (March 11, 1778) to the *syndic* and *gardes* "stating his intention to submit after the Sunday of Quasimodo to the ordinary examination for aspirants to the mastership in pharmacy in this city." This request was accompanied by a certificate of good morals, of Catholicity, and the license of apprenticeship, which he had obtained from the king because he was a *démonstrateur*. After many deliberations, and consultation with a lawyer, the *gardes* (J. F. Le Carbonnier, Le

The Picturesque Street of the Grosse Horloge in Rouen in 1785 (from a Steel Engraving)

The large hand of the clock has disappeared. To the right is one of the towers of the cathedral, which was spared in the great fire of June 11, 1940.

Carpentier, Jalama, Le Danoys the younger, and Le Chandelier) sent the petition by postilion to "Monsieur le médecin du Roy," president of the jury. He set May 11, 1778, for the first examination. Descroizilles presented himself on that day to these five gentlemen, who constituted the jury. The physician to the king opened the proceedings by delivering to the candidate a discourse in Latin, to which—it appears—the latter replied very elegantly in the same language. The *gardes* then put several questions to him, in Latin, on the fundamental principles of chemical pharmacy. They then adjourned until the next day, after drawing up the following minute, which is still preserved at Rouen:

Ce jourd'hui, onzième jour de mai mil sept cents soixante et dix huit, en l'assemblée convoquée pour le Ier examen de M. Descroizilles, le dit Sieur *aiant* bien satisfait, a été renvoyé au mercredy 13 du courant pour l'examen des drogues. Fait et délibéré, le dit jour et an que dessus. J. F. Le Carbonnier, Le Chandelier, Le Danoys le jeune.

On May 13 an additional approbatory report signed by these same examiners states that the recipient had properly "recognized the drugs submitted to him."

On the 14th, accompanied by Le Chandelier, the latest master to be certificated, and provided with a pick and a pouch, Descroizilles made a collecting trip of two hours' duration in the terrain around the mineral springs of St. Paul. Another series of plants, collected in his absence from the botanical garden of the city, was mixed with the specimens he brought back. He was required to give the principal medicinal properties of these items. In the silence of the cabinet, the *gardes* then deliberated alone on the choice of the preparations to be give for the *chef d'oeuvre, i. e.*, so to speak, for the thesis. The record of this main test reads:

This day, May 15, 1778, the assembly convoked for the examination of plants by M. Descroizilles, and having been well satisfied in this matter, it has been decided to give to the said gentleman the materials of his *chef d'oeuvre*, namely, to wit: the syrup of simple chicory, the syrup of chicory compounded, the powder of Diarrhodon, the electuary of Diascordium, the electuary of Diascartami, the emplaster of Vigo cum mercuro, worm oil, and as operation of chemistry: the butter and cinnabar of antimony, the spirit, the oil and salt of amber, the whole according to the Codex of the Edition of 1758.

Descroizilles immediately had a thin book printed containing his *chef d'oeuvre* and began the manipulations on the 22nd. The jury stopped him at eight o'clock in the evening while he was hard at work. The minutes of the following day read:

This day, May 23, 1778, M. Descroizilles has resumed the work of his *chef d'oeuvre*. All the operations and compositions being finished, it has been decided to recall the said gentleman finally for the interpretation of the Latin writers on the 25th of the present month. Done and ordered the said day and year above. J. F. Le Carbonnier, Le Danoys le jeune, Le Chandelier.

Finally, during the ninth and last session, he interpreted a Latin author, the Codex of Paris, and the ordinances of medicine. He then gave a final report of his *chef d'oeuvre*. The decision was:

Le dit Sieur a été reçu Maître Apothicaire d'une voix unanime.

During all these operations, Descroizilles had been supervised by the members of the jury in turn and was aided by Le Danoys the younger. The latter—who now would be called the assistant—received the title, *Maître tenant la queue de la poële* (master holding the handle of the pan).

As soon as he was certified Descroizilles was kindly invited to pay to the common fund of the community the sum of 700 livres, plus 6 livres for the poor of the general hospital (about 600,000 francs in 1951). During his oral examinations, and at the expense of the candidate, there were distributed 150 metal tokens of attendance, worth 2 livres apiece. (Some of these *jetons* have been preserved at Rouen.) Obviously the examiners were thus amply rewarded in those times. Also they had to be thanked individually, and the candidate was invited (without cost to him) to partake of the "sumptuous banquet," which concluded the examination service. The certificate of "Master of Pharmacy" was issued on May 17, 1778.[5]

At present a person qualified as a pharmacist remains so all his life, but at that time the apothecary was able to relinquish his title by returning his letter of mastership to the office of the corporation. Descroizilles retained his certificate only ten years. Confined behind a counter in a narrow but picturesque street, his investigative temperament could not adapt itself to that of a peddler of clysters. He loved to travel, even though the rules then in force forbade the apothecary to leave his city without permission.

In 1783 the celebrated Madame Roland wrote to her husband from Amiens: "But speaking of M. Descroizilles, who arrives today and departs tomorrow, regretting very much not to have seen you. He talked about peats, of analyses needed . . . he courts the world a little

[5] The diploma reads: L'an de Grâce mil sept cent soixante dix huit, le vingt septième jour de mai, devant nous Jean Claude Trugard, seigneur et patron de Maromme, conseiller du Roy, lieutenant général de police au baillage, Ville et Vicomté de Rouen, se sont présentés devant nous honorables h/les sieurs Jean Baptiste Le Chandelier, Charles Nicolas Le Borgne, François le Danoys, Henri Charles Fortin, Claude Ballière et Nicolas Vasselin, maîtres et gardes année présente de la Communauté des Apothicaires Epiciers, Ciriers, Droguistes et Confiseurs de cette ville, faubourgs et banlieue; lesquels nous ont présenté la personne de François Antoine Henry De Croizilles, fils de François, juré, apprenty dudit état sous Charles Denis Ballière le 6 juillet 1775, ils nous ont déclaré être capable et suffisant d'être reçu Mâitre dudit état d'apothicaire et dependances, par chef d'oeuvres ayant été dispensé du temps prescrit de son brevet d'apprentissage suivant les lettres à lui accordées par le Roy le 14 janvier dernier. A ces causes, du consentement du procureur du Roy, de ce siège, nous avons ledit François Antoine Henry De Croizilles reçu Mâitre dudit état d'Apothicaire et dépendances par chef d'oeuvres vu les lettres de dispenses à lui accordées pour par lui en jouir et l'exercerce jour et à l'avenir ainsi que les autres maîtres de celui art et de quoi nous avons dudit De Croizilles pris et reçu le serment au cas requis, fait et délivré comme dessus.

Trugard			C. Baillière
Le Danoys le jeune		?	
Vasselin	Henry Fortin	C. N. Le Borgne	?
Le Chandelier			?

I believe, for business reasons and speaks of mordants for dyeing...."[6] Descroizilles had become acquainted with Mme. Roland at Rouen in a literary salon on the Rue aux Ours. Her husband was operating a peat bog in Switzerland at the time.

Descroizilles was quite busy now with scientific journalism; as shown by the letters, often anonymous, which he addressed to Milcent, chief editor of the *Journal de Normandie*. Several of these "letters to the editor" are still in existence. He was quite enthused over the infant science of ballooning and corresponded with the noted pioneer balloonist Pilâtre de Roziers. Four days after the latter met his tragic death at Boulogne (June 15, 1785) Descroizilles wrote: "I have every reason to believe that this horrible event is the result of the explosion of the inflammable air (hydrogen) occasioned by the flame of the Montgolfier (hot air balloon) below...it is thus that the love of the Sciences has its heroes and its victims."

Toward the end of 1787 he made over his apothecary to Arvers, who later became a competent chemist and who had received his master's certificate on October 31, 1786. Descroizilles went into another business and moved his residence to the Rampart Beauvoisine in Rouen. In a letter to the Maîtres en Pharmacie (January 15, 1788) he made his apologies for no longer attending their meetings, because he had sold his pharmacy and was away frequently. "I will always retain the honor of being your colleague; permit me to demand the prerogatives." However, Mézaise, who had become *syndic*, had never forgiven him for having been flouted in the cider affair; by maneuvers unworthy of a member of the profession he succeeded in forcing Descroizilles to give up his master's certificate. Descroizilles wrote:

Rouen, February 18, 1788

Masters in Pharmacy of Rouen,

Gentlemen:

In the matter concerning ciders, after much care to avoid injuring the self-esteem of anyone, when I desired only to clear up a question which interested the whole province, the persecutions of Mr. Mézaise forced me to reveal publicly his errors, to say nothing more, and I was completely cleared by the higher court. It is the resentment engendered by this affair, which has brought to me a new attack today. I no longer have the same interest to defend myself against it, and the step which to me seems the quickest way to end it, is to request you, Gentlemen, to consent to the return of my certificate of mastership, thus announcing to you that it is no longer necessary to include me among the masters in pharmacy of this city, renouncing absolutely and forever this title. You understand that I ought no longer to bear the burdens of it. It has brought me no glory up to the present except that it gave me the honor of calling myself your colleague. However, it has cost me to have something in common with Mr. Mézaise, and it may be worth while that I will always seek to point out everywhere he may be some of the esteem which I hold besides for the companies of which he is a member, though actually it makes little difference what opinion of me is held by Mr. Mézaise and all those whom he has known how to place in his interests ....

A certain Masset, usher, has left in the *Archives des Apothecaires de Rouen* an account, full of queer errors in spelling, of how he delivered to the Maîtres the letter of resignation and the certificate of mastership of our François Descroizilles, who now was to show the true measure of his ability.

[6] Taken from CLAUDE PERROUD, "Amateur d'autographes," 1914, p. 168.

BLEACHING BY CHLORINE

Scheele, the Swedish chemical genius, announced in 1783 the discovery of chlorine, which he had made two years previously in his modest apothecary's laboratory. Up to that time thread and vegetable fabrics had been whitened by exposure to sunshine. Berthollet[7] quickly recognized the part which chlorine might play in the bleaching of cloth. Moreover, James Watt, who was then one of his pupils, hastened to return to England and introduce the discovery there. A little later he wrote to Berthollet: "I have successfully bleached 500 pieces at Macgregor's, a Glasgow manufacturer, and from now on the method may be regarded as the best, the quickest and the most economical."

De Grandcourt, another pupil of Berthollet, provided with letters of recommendation, took the stage coach for Rouen in 1788 in order to persuade the manufacturers of that region to adopt the new procedure.

From 1780 Flavien Marie Scanegati, member of the Académie of Rouen, physicist and author of all sorts of practical discoveries, had occupied a plot of ground in Rouen just across from the Porte Guillaume-Lion, and

Porte Guillaume-Lion, Rouen

All this quarter of Rouen was destroyed by the Germans in 1940.

had erected there at 12 Quai de Paris a demonstration laboratory, a classroom, and a salesroom for apparatus, on the site later occupied by the "Brasserie de la Marine."

It was in this room, belonging to Scanegati, that de Grandcourt planned to carry out a convincing demonstration of the process in order to interest the financiers. Among those present were de Fontenay, manufacturer and mayor of Rouen, and Descroizilles, ex-apothecary

[7] LEMAY, P., AND R. E. OESPER, J. CHEM. EDUC., 23, 158, 230 (1946).

François Antoine Henri Descroizilles and His Signature. Portrait from a Miniature (in the Rouen Museum) by Judelet

but permanent professor of chemistry. The demonstration turned out miserably; some of the thread was bleached only on the surface, while other samples were burned and rendered useless. Sieur de Grandcourt hurriedly disappeared from Rouen.

Nonetheless the disappointing exhibition left Descroizilles interested. He persuaded de Fontenay to combine forces with him, and the latter provided funds for attempts to perfect the Berthollet process. The experiments were carried out in 1789 at Lescure-les-Rouen, but they resulted in nothing but disappointments and the loss of considerable money. The crux of the process obviously lay in the necessity of finding some way of determining, and so controlling, the concentration of the chlorine water. At last, in 1791, Descroizilles devised the apparatus which he named the *berthollimètre;* the earliest buret. His procedure was based on the ability of chlorine gas, either dissolved as such or combined as hypochlorite, to discharge the color of indigo. At the close of his career he wrote: "Among the small number of procedures which I have discovered, few have pleased me as much as this one" ("Alcalimètre," 4th ed.,p. 86).

The buret was known successively as *berthollimètre, chloromètre,* and *polymètre.* It consisted of a glass tube, 20 to 25 cm. long and 14 to 16 mm. in diameter. The closed lower end fitted into a stand, while the open upper end was provided with a flared rim. The engraved scale had 24 large divisions, numbered from 1 to 24, each divided into 4 subdivisions. There was also a similar division or space between the bottom of the vessel and the lower end of the scale marked 0. This space was intended for the *berthollet* (chlorine water) to be assayed; it, like the other 24, had a volume of 2 ml.

The berthollimetric solution was prepared by dissolving 8 g. of indigo in 66 parts of concentrated sulfuric acid; a little hot water was added, the mixture was kept warm for an hour, and after cooling was made up to 800 ml. with distilled water. The solution had to be stored away from the light in hermetically sealed crystal glass vessels. Descroizilles found that ordinary glass produces alkalies which decrease the strength of the standard solution.

Some French writers have mistakenly attributed this discovery to Gay-Lussac, who (born 1778) was only 13 years old at the time. Furthermore, the latter, in 1824, wrote in the *Annales de Physique et Chimie:* "...in the arts, where it is imperative that the determinations be completed promptly, preference has been given to the procedure of M. Descroizilles, which is based on the property of chlorine to decolorize indigo...."

The number of divisions of the indigo liquor that could be decolorized when added to the fixed volume of the *berthollet* gave the *degree Descroizilles* or chlorometric degree. To be effective and yet not to damage the cloth, the *berthollienne* solution ought to give four degrees in the *berthollimètre.* Some other terms which were in daily use in the Lescure establishment were: *berthollienne* bleaching, *berthollienne* bleachery, to *berthollet* a cloth, the *berthollierie.*

In the fourth edition of his "Notices sur l'Alcalimètre," Descroizilles was able to write with justifiable enthusiasm:

> It is evident that this capital discovery in the art of bleaching is in great measure responsible for the prodigious increase, since then, of the manufacture of cotton fabrics, which has more than decupled in Europe within these last thirty years.
>
> Formerly, when a fine cotton cloth, intended to be sold as white goods came off the loom on October 15 or in the succeeding five or six months, it was necessary to wait until the end of spring before it could be delivered white to the trade; and besides during this interval, the hurricanes, the prolonged rains, the hail, the floods, the mud of the rivers, the cattle, the poultry, the dogs, etc., often reduced to a very low figure the price of the fabric, which had been made with so much care, and for which it was necessary to wait so long. Now, in contrast, even in the most severe weather, a cloth of this kind receives the most perfect white without ever having been exposed to the injuries from the atmosphere, and without being dragged over the muddy field, covered with rough stubble from the cut fodder.

As was Berthollet's intention, many fields were consequently released for agricultural purposes. It was estimated in 1818 that the wages paid to the workers using the Descroizilles method amounted to 1,000,000 francs. The first bleachery of de Fontenay was given up; a second was established at Lescure by the Prevel

brothers and Descroizilles himself, then a third with the Chaleil brothers and Delamare, a fourth at Maromme, a fifth at Petit Quevilly.

Rouen and its environs thus became the cradle of cotton bleaching. In this connection, Descroizilles received his only decoration: the jury at the Rouen Exposition in 1806 awarded him a gold medal "for having founded one of the most perfect works for *berthollienne* bleaching which exists in France." However, the life of the inventor is not all peace and quiet; in 1807 some badly bleached cloth, fraudulently brought in from England, was put on the market to discredit the discovery (which came during the reign of Napoleon I). As may be learned from the *Annuaire de la Seine Inférieure* of 1807, Descroizilles fought vigorously to restore confidence in his process.

DURING THE REVOLUTION

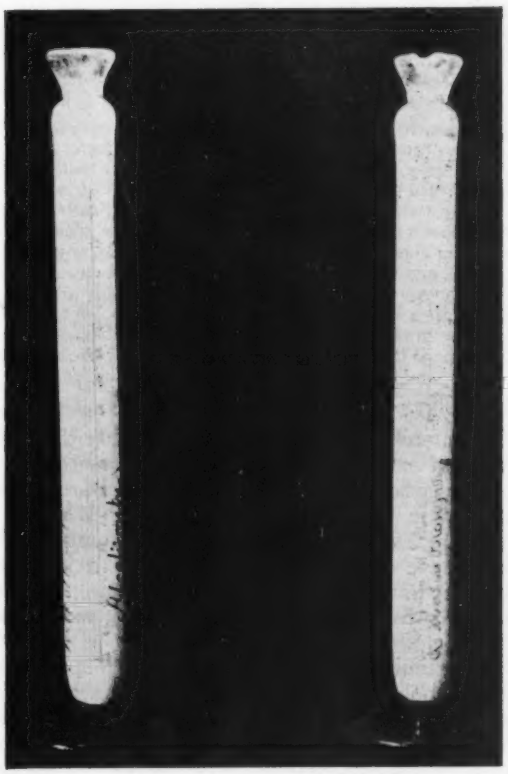
Previous to 1789 Descroizilles was very closely linked with M. and Mme. Roland, the future Brissotins. As was mentioned above, he had known the latter at Rouen at the home of the Malortie sisters, whose name appears frequently in the history of the region at this period. After the Insurrection of August 10, 1792, Roland was again made Minister of the Interior, and he chose Descroizilles to supervise the stocking of the markets in the Dieppe district. However, a major difficulty arose on September 29, 1792, when he tried to impose the tax of 4 francs per bushel of grain going to market. Naturally, a black market sprang up and he had to abandon all administrative functions and enter the political conflict. He took part in the riots which preceded the execution of Louis XVI (January 21, 1793), and sent to the Convention a note which was posted in the 84 departments. In the *Journal de Rouen* of May 25, 1793, he wrote: "The Assembly, like the Republic, should be one and indivisible." After the establishment of the Committee of Public Safety, Descroizilles was arrested in September, 1793, and confined at Rouen. He immediately appealed to his friends Arvers and Chaptal, and to his sister Marie Françoise, who had just married (September 23) Quesnel. The latter had been made constitutional curé of Dieppe because "he had deserved well of la Patrie by erasing the episcopal aristocracy." Since the Republic needed chemists, Descroizilles was set free, and on December 30, 1793, was charged by the Convention to go to Dieppe to study the problem of the production of artificial niter. Meanwhile his friend Roland had killed himself (November 10, 1793) on learning that Madame Roland had been guillotined two days previously. On January 13, 1794, Descroizilles' duties were extended; he was appointed Inspector of Powders and Saltpeters for the whole department. It is likely that the experiments at Rouen and Dieppe on the production of saltpeter (starting with fish) were unfruitful; they were probably reported in a pamphlet: "Essai sur l'art du salpêtrier," which has been lost. All that is known is that he set up a niter bed with some manure in the Church of St. Rémy of Dieppe, not far from the Église St. Jacques where he had been baptized. The Descroizilles works was closed on July 8, 1795, and the church turned over to the cult of Reason.

A rather pale Girondin, an indifferent Montagnard, he referred to Louis XVIII in one of his papers in 1819 as "the beloved monarch who has given the Charter to France." According to a local sheet (*Chronique nationale de 1792*) Descroizilles was "an orator without fire." This same periodical reproached him for having "acted like a manipulator chemist and to have substituted a refrigerant for a fuel."

IN PARIS

Descroizilles moved to Paris in 1806, and this same year he published his chief work, "Notices sur l'alcalimètre." It contained the earliest exact experiments on the assay of commercial sodas, procedures which are still used today, except for the form of the buret. The fourth edition, published after Descroizilles' death, was dedicated to Alexandre de Fontenay, his benefactor. The book includes a set of lectures on chemistry as applied to commercial sodas and potashes, and also many remarks and prophetic visions which show that Descroizilles to the end of his life retained full possession of his faculties and fertile imagination.

The alkalimeter at first was given the same form as the berthollimeter; later the constriction was omitted



The First Alkalimeter of Descroizilles

so that a hydrometer could be introduced; the opening was coated with white wax to retain the drop. The capacity of the apparatus was 70 to 80 ml. The graduation from the top downward read from 0 to 72, in later models from 0 to 100. The distance between two consecutive lines corresponded to 5 cg. of concentrated sulfuric acid plus the quantity of water necessary to make a demimilliliter, that is, 9° on the Baumé hydrometer or 1 g. per 10 ml., or 100 g. per liter (a little more than twice normal). He assumed that the acid at his disposal was perfectly pure. He placed drops of "syrup of violet" on a saucer, or he used small squares of paper impregnated with red and blue litmus. During the titration he brought drops of the liquid to these external indicators with a glass stirring rod. He called attention to the errors occasioned by the sulfide in carbonates, coming from the Leblanc soda process. Though it would be absurd to claim that he knew anything about the theory of indicators, it should be pointed out that he observed that in the analysis of vinegar the quantity of soda consumed was not the same when litmus rather than sirup of violets was employed as indicator. He cautioned his fellow chemists against Paris litmus which he found to be nothing but the juice of black nightshade. The invention of the alkalimeter made it possible to set up some rules controlling the manufacture of caustic alkalies from lime. Descroizilles corrected some mistakes in this regard which were contained in the popular "Traités de chimie" of Fourcroy and Thenard. It can be justly stated that Descroizilles was the forerunner of standardization of merchandise when he wrote:

> It is easy to see the advantage presented to customers by a seller who can say to them: "I offer you *graduated potash* or *soda graduated* to such or such alkalimetric hundredths and at such and such price. You now have at hand an instrument with which you can, without chemical knowledge and without calculations, assay or have assayed under your eyes, one hundred samples in one day, and thus verify the qualities which I state to you at my current price, on my invoices and on my barrels. The latter are closed with cords, whose two ends are held together with a lead seal carrying my mark; you can have every confidence in them." There is no reason to doubt that the merchant, who is the first to offer such guarantees, will obtain great preference and that he will finally compel the others to follow the same course.

His interest in caustics led him to study the manufacture of soap. He always paid close attention to the Leblanc soda process; he simplified the Darcet assay, as given in the "Art du Savonnier." "When I am improving a soap factory, I prefer non-sulfuretted sodas, and I have sodium sulfide delivered as it is needed. This preparation will have constant qualities, because it can always be conveniently analyzed by a given method" ("Alcalimètre," 4th ed., p. 150).

At all times, Descroizilles could be seen approaching ideas of political economy, which are now taken as a matter of course. Suddenly he uttered a prophetic vision: "It is never necessary to despair that time will not bring efficient methods of production. Doubtless, we also will have them for indigo...."

In 1795 he made a statement that bears on microchemistry. He was already using platinum chloride to distinguish between potassium and sodium sulfate. However, he reserved this test for those who had but little knowledge of chemistry. To workers and soap makers, he said:

> . . . if the crystals have the form of small diamonds, if they are compact and if they dissolve with difficulty on the tip of the tongue, if they retain their transparence in dry hot air, it is sulfate of potash; the potash being tested is pure. But if the crystals are very elongated, very transparent, if they are only slightly compact and dissolve readily on the tip of the tongue, if they lose their transparency in hot, dry air, if they fall to a light powder, very white and very opaque, if they redissolve in water very easily, it is sulfate of soda ("Alcalimètre," 4th ed., p. 62).

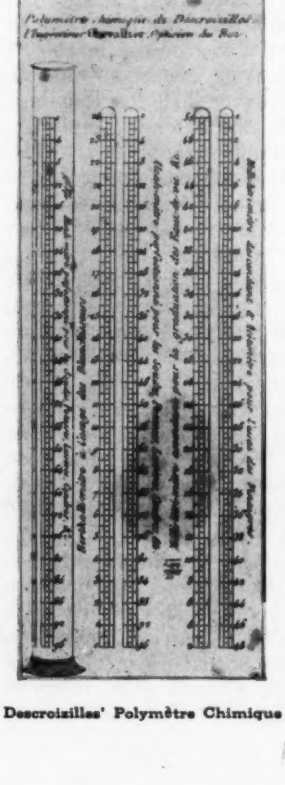
Quite early in his career he noted that all lime which had been burned with wood contained potash, but this was absent when coal was the fuel.

RESEARCHES IN ACETIMETRY

Around 1818 Descroizilles turned his attention to pyroligneous acid, which, in his opinion, would yield a commercial vinegar if diluted with water and mixed with new sweet Burgundy wine. He advocated the use of iron acetate in dyeing. These interests led to the construction of his *acétimètre*.

In calibrating the instrument he used solutions of soda, potash, lime, magnesia, oxides of zinc, copper, etc., as standards; he found soda was the most satisfactory.

The *acétimètre*, for the same reason as the *alcalimètre*, was graduated from 0 to 50 from top to bottom and had a capacity of 50 ml. The fixed 10-ml. volume below the mark 40 corresponded to the sample of vinegar being tested. He judiciously pointed out that "according to the rate at which



Descroizilles' Polymètre Chimique

Descroizilles' Couloire

This device served to strain caustic soda solutions prepared from lime and sodium carbonate. It embodies the filtering principle originally devised for the preparations of coffee.

the red color of the litmus is discharged, it can be judged whether the vinegar has been adulterated or not with sulfuric acid."

The soda solution was standardized against sulfuric acid by means of the alkalimeter. In order to have caustic soda at hand, Descroizilles devised the *couloire* (colander), similar to his coffee-maker, in which he placed the mixture of lime and sodium carbonate.

Toward the close of his life, Descroizilles combined the following in a single buret, which he called *polymètre chimique:* (1) the *berthollimètre;* (2) the *alcalimètre;* (3) the *millilitremètre ascendant* or graduation tube; (4) the *millilitremètre descendant* or *acétimètre.* Although this apparatus did not enjoy much success after 1830 it nevertheless sums up a whole life of labor devoted to chemical analysis. It is always easy to improve a device after the basic principle has been discovered by someone else.

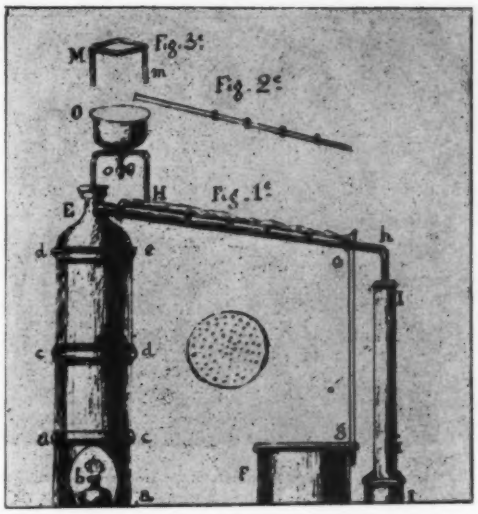
THE PORTABLE STILL

Though kept extremely busy with chlorine bleaches, alkalies, vinegars, and ciders, Descroizilles never lost interest in sugar, as is evident from his statements: "Pupil of Hilaire Martin Rouelle, I assisted him more than fifty years ago to extract sugar from the beet..." (*i. e.*, prior to Marggraf's discovery) and "during the winter of 1816–17, I had the idea of fermenting some sugar molasses to learn their production of alcohol. Those from Paris gave less than those in the provinces because they are purified with animal black...."

Later it will be shown how Descroizilles came to invent apparatus for the analysis of wines and brandies, to construct an alcoholometer and alcoholometric tables; the degree Descroizilles was subsequently superseded by the degree Gay-Lussac.

A patent and a reward were granted in 1810 to a certain Mr. L., who claimed that he had determined the alcohol content of a wine by placing the hydrometer in the filtrate after the sample had been treated with chalk. Descroizilles refuted this determination scientifically, and showed that the chalk did not precipitate all of the salts contained in the wine, and that it was better to obtain "all the *eau de vie* in 2 or 3 deciliters of wine in the course of a half hour by distillation." Moreover, he had in mind the professor who could show his students products distilled during the lecture, the physician who might wish to administer certain distilled liquors, which occasionally were not available in the pharmacies, the vintner when he wished to rack off his wine, the inspector who needed to examine suspected wines.

Including its accessories, Descroizilles' small portable still, made of tin, weighed only 3.350 kg. By means of this apparatus and the Cartier hydrometer, then in use, Descroizilles constructed some tables giving the percentage of spirits of 21¾ degrees (which at that time paid only a simple tax). He discussed the sources of error but does not seem to have taken account of the importance of temperature. Nevertheless, he came to the very impressive conclusion: "The wines which lend themselves well to longer periods of preservation are also those which, in equal amounts, carry the most to the brain of the imbiber."



Small Tin Portable Still for Determining the Alcoholic Content of Wines, Etc.

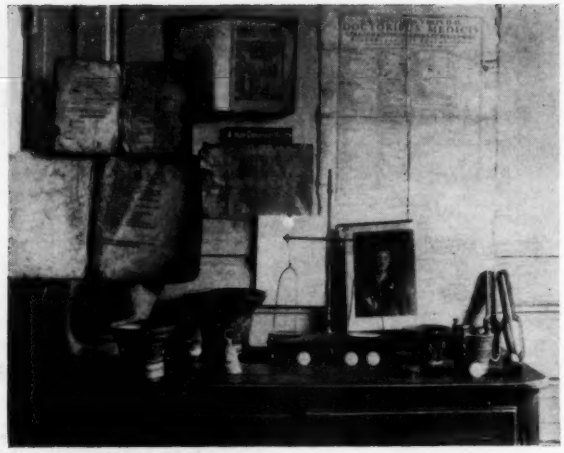
OTHER PRACTICAL RESEARCHES

The *Précis* for 1771–80 of the Académie de Rouen contains his "A chemical analysis of the waters of the foun. tains and wells of Rouen." As was mentioned, Mme Roland alluded to his interest in mordants. She doubtless was referring to stannous chloride or "muriate of tin." When the salt tax was removed, Descroizilles brought the price of this tin salt down from 50 to 4 francs per kilogram. He made efforts to produce it in very large crystals for dyeing printed cottons and for a long time he alone supplied the department with this important item. In connection with these studies, he showed that English tin contained up to 1/754 of arsenic, and not carbon, as the "deposit which is found as a black powder on the bottom of the containers" had been believed to be. These deposits gave off a characteristic garlic odor, and poisoned dogs, cats, etc.

The impure hydrochloric acid derived from the bleaching liquors did not yield him well-crystallized tin chloride (he was still unaware of the existence of hypochlorous acid). In the analytical summary of the *Travaux de l'Académie de Rouen* for 1807 he also described a method for obtaining copper sulfate and zinc sulfate in batches as large as 300 kg. His product sold at a better price than the material which was coming from Salzburg and which contained copper and iron.[8]

In the course of his study of bleaching liquors he passed chlorine into a water suspension of chalk, but he apparently made no claims to the discovery of chloride of lime; later he referred to it as Tennant's powder. Always interested in factors affecting yields, he found that the output of chlorine was increased when 1:1

[8] "Notice sur quelques sels métalliques employés dans les arts," 1787.



Items Belonging to Descroizilles Shown at the Rouen Exposition of 1902

sulfuric acid was substituted for the concentrated acid hitherto used by Berthollet. With respect to the checking of starting materials, a question of vital importance in his opinion, he stated that the bertholimeter was the only practical means of judging the various kinds of manganese dioxide offered for sale.[9]

In his role as owner of a factory Descroizilles was of course interested in fire-fighting. He notes[10] that a small quantity of water, instead of extinguishing a fire as a sufficient quantity does, causes it to spread more rapidly. He sought the explanation for a long time but in vain. He made some trials along these lines to refute statements issued by Van Marum, the discoverer of ozone, and also in the presence of an official he carried out a contradictory experiment on some sheds coated with pitch, to confound "a man said to be from Paris and a tailor, who supposedly has a secret liquid for the extinction," a liquid which allowed one of the wooden huts specially built for the occasion to be consumed completely.

Descroizilles proposed the establishment in the capitals of Europe of a "school of pyronomy" where men could be taught to preserve themselves against the ravages of fire. He required portable pumps in his factories, pails filled with ordinary water in the summer, brine in the winter, etc. "We thus have had," said Descroizilles (in the *Archives de la Société d'Émulation de Rouen*) "the sweet pleasure of saving our neighbors."

In another paper[11] he dealt with distillation, especially with the way to prepare incorruptible distilled waters, refluxed over inodorous plants. In this connection, he pointed out the modifications to be made in the still if the plant was to be distilled over an open flame. Two years later he published a paper in *La France littéraire* on "The art of engraving glass with fluoric gas." Girardin (Vigie, Dieppe, 1847) reported also that Descroizilles spent some time on the retting of flax, and on the form which shoes should have in order to wear better. He advocated heating bakers' ovens with coal, remarking that the bread thus prepared did not have a bad taste ("Alcalimètre," p. 109).

In 1819 Descroizilles published a new work: "Method of preserving corn, rye, etc., from all alteration." Though this method did not have much success at the time, it gave rise eventually to the construction of modern silos (he called them *conservatoires*) for storing grain to protect them from rodents and weevils: "The cities will not be exposed to the lack of bread, fortified places can have reserves of grain proportional to the garrison and the density of the population." He also recommended that fodder be compressed hydraulically to one-fifth its volume.

As was seen, Descroizilles had to fight against false practices in industrial matters, and in 1819, after peace was declared, English cloths again appeared on the French market. In a new brochure (76 pages.) "Estampillage enrigistré" (Registered stamping) published at Rouen, he proposed a plan which was not adopted, at least not at that time. The French products were to receive a round stamp with a series of numbers indicating the *département*, *arrondissement*, and the district; the foreign products brought into the kingdom would be given an hexagonal stamp when the duty was paid, and an oval stamp would serve for objects manufactured prior to the promulgation of the law. A prodigious staff would have been needed to put this idea into practice at that time. . . . Certain ideas contained in this brochure have proved to be useful in the present way of living, as for example in the license plates of automobiles.

CONCLUSION

Descroizilles' son Paul (1793–1863) inherited some of his father's talents. He invented a lixiviation apparatus and a device for flaming cotton textiles as they came from the loom. A silver medal was awarded for this discovery. He also devised a heating stove which was still sold in Rouen under the name Descroizilles in the period between the two world wars.

The elder Descroizilles allowed himself to be stripped of all his property. In his last moments he wrote: "I will never be accused of being actuated by personal interest, nor by base motives of any kind." After a life worthy of that of his ancestors on the Place Royale of Dieppe, he sank to a condition quite close to poverty. However, he had the satisfaction of knowing that he had contributed to the advance of science, that he had invented a fundamental system of chemical analysis, that he had made the fortune of an entire region, and that he had saved the lives of many seamen.

The register of the parish of St. Roch in Paris contains the bare notice of his death: "April 15, 1825—François Antoine Henri Descroizilles, age 74 years. Employed at the Ministry of the Interior, residing at 7 rue Neuve des Bons Enfants." The body was interred

[9] *Journal des Arts et Manufactures*, 1, 156 (1794). This short-lived periodical (September, 1794 to September, 1795) issued only 12 numbers.

[10] *Ann. chim. phys.*, [1] 51, 27 (1804).

[11] *Ibid.*, [1] 57, 175 (1806).

in Père Lachaise cemetery, and 30 years later the remains were scattered to the four winds.

Rouen named a small street after him; Dieppe put up a tablet; chemistry still owes him a worthy place of honor.

Perhaps it was such as he that Lecomte du Nouy had in mind, when he wrote in his "Human Destiny": "The destiny of man is not limited to his existence on earth and he must never forget that fact. He exists less by the actions performed during his life than by the wake he leaves behind him like a shooting star. He may be unaware of it himself. He may think that his death is the end of his reality in this world. It may be the beginning of a greater and more significant reality."

DESIGN THAT REPORT!

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Too many courses in technical writing still reveal their being born of traditional composition courses, while too few possess any close relationship to actual writing situations found in industry. Contact with professional technical report writing problems has indicated two main difficulties: first, the failure on the part of the writers to *design* their reports to fit a specific situation, purpose, and audience, and second, a lack of knowledge of the *process* involved in writing. This is not a criticism of the technically trained men, but rather of the education given them. To ask a person to design a gear assembly for a particular mechanism without providing both the context of the problem and a training in the required skills would be considered foolhardy; yet that is precisely what is being done in a great many report-writing courses.

Experience teaches that too many writers fail to analyze the report-writing problem which faces them. Instead of first considering how the conditions of the assignment, the purpose of the report, and the users of the report should influence their work, they want to start writing long before they know what the report is to be, what it is to do, what it is to say, or who is to use it. Furthermore, competent technical men often fail to consider how the time given them to write a specific report affects what should be included and how long the report should be. If what they feel has to be included is more than they have time to do, they work overtime and complain of the load they have been given. Of course, many times the assignment is given neither clearly nor concisely enough; also too much may be expected in too short a time; however, more often than not, the writer has failed to recognize the influence of the time element in the assignment which produces extra work.

Likewise they often fail to realize how they, as writers, should be affected by the aid which is available to them and by the amount, kind, and sources of accessible information. One man was faced with the task of periodically compiling a master report from those submitted to him. Although he was an excellent engineer and succeeded in filing a good report, he was doing a great deal more work than was required because he completely rewrote all the material submitted to him. The aid which he got was not being fully utilized, for his work would have been much easier had he sat down with his assistants and provided them with the over-all pattern of the master report, making sure that each understood his part in the formation of the whole. He could then merely have compiled the report, adding whatever was necessary, rather than have rewritten it.

In addition to the elements of time, information, and aid, two other important conditions must always be taken into consideration: the specific requirements imposed upon the writer and adherence to company policy. If the request for the report is accompanied by "include the causes of production line stoppages last month," the content of the report and the performance of the writer are affected by that order. Moreover, general company policies and style-sheet requirements are always in the background and must be considered.

Obviously a report which is to be used for later reference requires coverage, data, and detail different from that in a weekly progress report; yet many experienced chemists do not realize that these differences exist because they have not been made conscious of the requirements which the purpose of the report places upon them. For example, at one concern a large staff of chemists was employed in the experimental laboratories, and part of their duties was to record their experiments and findings so that these could be used later, whenever the need arose. These reports proved, too often, useless for such purposes, for not only could the results not be clearly understood but, sometimes, the experiments could not even be repeated. An analysis of the situation indicated that the chemists did not realize that reference use of the report placed special requirements on them as report writers. At the time of writing, the experiments were fresh in mind; the writers were comfortably in the context of the situation, and little thought was given to what would be required by the

reader in order to understand the account when he came to it "cold," sometimes years later.

An example from another concern also reveals this same failure. One of the men presented a long report which was to be used for constant reference by non-technical personnel; yet the work was rendered almost useless because of the general "layout." After a table of contents, thumbtabs for the main sections, and an index were added, the report became both usable and valuable. These devices are quite common. The writer knew of them but he neglected to use them because he had not *designed* his report to serve its purpose.

More and more, writers in industry are becoming aware of their readers' interests. They are placing conclusions, summaries, and recommendations at the beginning of the report because the administrators are most interested in such material. The more detailed material is placed toward the end of the report, for often only the specialist assigned the job of checking these details will read it. The more widespread use of such devices as statements of purpose and background, abstracts, summaries, and conclusions at the beginning of a report is ample proof of the writer's growing awareness of the reader.

In addition the writer should consider his own background in determining what is required in the report. If possible he should answer the question "Why was *I* asked to write this report?" In many cases the answer will provide an indication of what should be in the report or what general approach should be used. For instance, in one concern two men with quite different backgrounds work in the same department. One has worked his way up through years of practical experience in several concerns, and the other is a college graduate with a few years' experience in this particular concern. If a writing assignment were given to the older man, he could be quite sure that the "boss" wanted the views of a practical man with a wide background of experience, and he should emphasize his material accordingly. If an over-all picture were needed, the younger man would be asked to write the report. In both cases the effectiveness of the writers would be increased by an analysis of what their backgrounds could add to the writing requested of them.

Recent classes in report writing offered to engineers and chemists actively engaged in industry revealed, in almost all cases, a lack of understanding of the activity of writing or of the process involved. This is not surprising, for the emphasis in their training was on the finished product, not on the activity which produced it. As a result, when faced with a writing problem they thought in terms of the finished product. They tried to write the report without planning it first, like a carpenter trying to build a house without blueprints. Only confusion and difficulty could result.

Once they started with the analysis of the writing situation—the assignment conditions, the purpose of the report, the audience, and their own background—they found writing much easier. When they had these restrictions well in mind, they found that they could focus on the topic of the report more effectively, and, of course, they could more easily tell what material was necessary because they knew what was expected. The gathering, evaluating, and selecting of material became a relatively simple task because the analysis of the situation had provided them with the necessary standards from which they could work.

When the selection was completed, however, they found themselves facing a completely different task, one of constructing rather than analyzing. The arrangement of material into logical patterns, into main and subordinate classifications, into meaningful relationships, became easier because these considerations depend to a large extent on the writer's purpose and intent, on what he wants to do. Once they knew what they were trying to accomplish, they could, by keeping their purpose in front of them, organize the material in meaningful stages and indicate the relationships between the stages. They began to realize that these relationships were what gave their work real meaning and value. More important, they found that the prospect of actually writing the report no longer seemed overwhelming. They had reaped the fruits of designing their reports; they knew where they were going and what they wanted to say.

Of course, they had not reached the end of the writing process; they were still faced with the writing and rewriting, but their particular difficulties had, in the main, been overcome after they had gone through the planning process. The rest seemed, in most cases, to take care of itself. Surprisingly enough, many of the grammatical and stylistic problems eliminated themselves, for they seemed to be the result of confusion and indirection rather than of a basic lack of knowledge.

These experiences with actual industrial writing problems suggest that we who teach technical writing need to adjust our courses so that they more closely resemble the professional situation. They further suggest that we need to train our students to analyze the writing problems and to provide them with some understanding of the process involved in writing. It seems also that we need to shift our emphasis from the exactness of the finished product to the activity of writing. We need to help the students reach the finished product; moreover, we should criticize the work from the point of view of how well it achieves its purpose and fits the situation rather than merely correcting it in a grammatical vacuum.

One thing is certain: a *realistic approach* to technical writing is more likely to be found through actual contact with industrial writing problems than by simply continuing the traditional composition approach so often used. This of course places a tremendous burden on the shoulders of the teacher because it means, first, that every writing assignment must be given a context—that is, a specific situation and problem must be created for each report the student is to write—and second, that each student must be trained in the skills of the writing process. This is the realistic approach, for it is the one that best simulates professional conditions.

EXPERIMENTS ON RADIOACTIVITY IN THE FIRST COURSE IN COLLEGE CHEMISTRY[1]

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Most modern texts in introductory chemistry devote one or more chapters to the subjects of radioactivity and nuclear energy. Only a few publications describe suitable and related laboratory work. G. A. Scherer[2] has outlined some experiments which are relatively inexpensive. These include the use of a very simple Wilson cloud chamber for obtaining alpha tracks, an electroscope for the measurement of activity, and a method for the separation of thorium from uranium. R. R. Williams, *et al.*[3] have described the use of a Geiger counter for a series of quantitative measurements, the exercises being incorporated in a course in introductory physical chemistry.

The experiments described below have been selected in part from the above after consideration of the ability of the average beginning student, the importance of the principles presented, and the cost. The use of the experiments over a period of three years has indicated that the material and techniques are readily handled by the students. The four important points emphasized by the exercise are as follows: (*a*) an introduction to some methods for the detection and measurement of activity, (*b*) a study of the penetrating powers of beta and gamma radiations, (*c*) an example of separation of radioactive substances (thorium from uranium), and (*d*) the determination of the half-life of a synthetic isotope. A working knowledge of these subjects certainly is necessary for a basic understanding of the behavior of radioactive substances.

In actual laboratory practice the students are required to complete the experiments in two three-hour sessions. Although a limited number of sets of equipment are available, sufficient time is allowed for each student individually to carry out the work.

THE DETECTION AND MEASUREMENT OF ACTIVITY

Wilson Cloud Chamber. The observation of fog tracks of alpha particles may be accomplished by means of a simple cloud chamber described by Scherer.[2] A small sample of pitchblende, a source of alpha particles, is glued inside an Erlenmeyer flask. The flask is partially filled with water containing a blue dye and a rubber bulb is attached to the neck of the flask. Supersaturation is obtained by alternately squeezing and releasing the bulb, and cloud tracks appear at a statistical frequency. Such a simple device may be employed successfully, but requires some operating skill and patience.

Electroscope. An electroscope constructed from a chalk box has been described (ref. 2). Two aluminum foils, one flexible and the other rigid, are attached to a brass rod which is suspended through a hole in the top of the box and is held by an insulating plug of sulfur. A small brass ball caps the outer end of the rod. The box is fitted with a glass window to shield the foils from air currents.

The electroscope is charged and the leak constant is determined. Various samples of uranium minerals are placed beneath the foils of the electroscope, and the rate of fall of the movable vane is compared with the leak constant.

Geiger Counter. A variety of relatively inexpensive Geiger counters sensitive to beta and gamma radiations are available commercially or may easily be constructed.[4, 5] In this particular instance radioactivity demonstrators[6] (Figure 1) were purchased together with

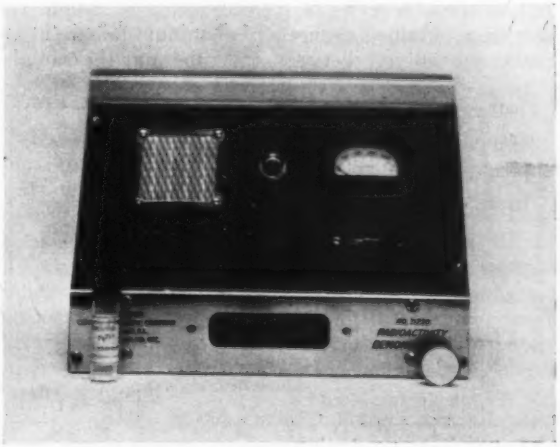

Figure 1. Radioactivity Demonstrator with Beta and Gamma Sources

beta and gamma sources at a cost slightly above $100 each. The principal desirable features of any instrument for this purpose are: simplicity and ruggedness of construction, provision of a loud-speaker for audible pulses, a neon light for visible indication of counting,

[1] Presented at the 118th Meeting of the American Chemical Society, Chicago, September 4, 1950.

[2] Scherer, G. A., J. Chem. Educ., **26**, 111 (1949).

[3] Williams, R. R., W. H. Hamill, and R. H. Schuler, J. Chem. Educ., **26**, 210, 310, 667 (1949).

[4] Levine, H. D., and H. Digiodanni, Atomic Energy Commission Paper NYO-103, January, 1950.

[5] Hamill, W. H., R. Williams, and C. Mackay, J. Chem. Educ., **28**, 98 (1951).

[6] Supplied by Tracerlab, Boston, Massachusetts, or Central Scientific Co.

and a rate meter (calibrated in counts per minute) for sustained quantitative measurements.[7] There should be no exposed points of high potential, nor any danger of accidental electrical shock from any part of the equipment. In order to prevent application of too high a potential to the Geiger tube by inexperienced students, which would result in a shortening of tube life, we installed a five-megohm potentiometer at the rear of each instrument used for these experiments and connected the potentiometer in series with the rheostat which controls the potential applied to the tube. The potentiometer was preset to allow a maximum of 1025 volts across the tube, a value well within the plateau region of the operating characteristic of the Geiger tube supplied with the instrument.

The students are instructed in the operation of the instrument, the method for determining the background level, and the procedure for measuring activity. Practice is readily obtained by providing a variety of radioactive minerals.

THE PENETRATING POWERS OF BETA AND GAMMA RADIATIONS

Absorption of Beta Radiation by Aluminum. A small sample of Pb^{210}, a beta source, is mounted on a small metal bracket and the bracket fastened to the chassis of the instrument directly in front of the Geiger tube in place of the cover which protects the tube when not in use. A series of measurements of counts per minute is obtained as sheets of aluminum foil are interposed successively between the tube and the sample.

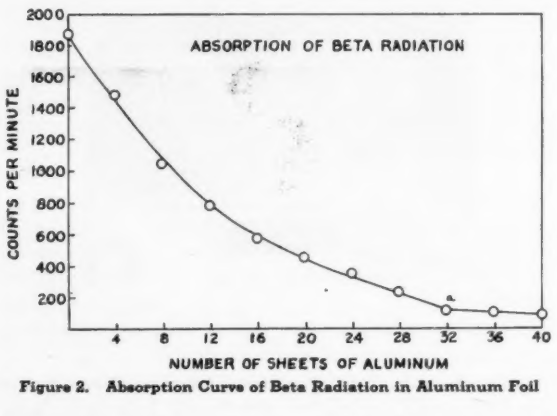

Figure 2. Absorption Curve of Beta Radiation in Aluminum Foil

Figure 2 illustrates a typical result obtained by the students. As an increasing number of sheets of aluminum are added, the intensity of radiation at the Geiger tube gradually decreases until the background level is reached. The mass of material necessary to absorb the beta radiation completely is indicated by the point *a* where the background level is first reached. A more accurate measurement would call for a plot of total absorber thickness, usually expressed in mg./cm.^{2}, versus counts per minute, corrections being made for absorption due to air and the walls of the Geiger tube.

[7] Undoubtedly a scaler is preferable for advanced work, but the intricacies of scaling circuits are harder to teach beginning students, and the cost of scalers is prohibitive.

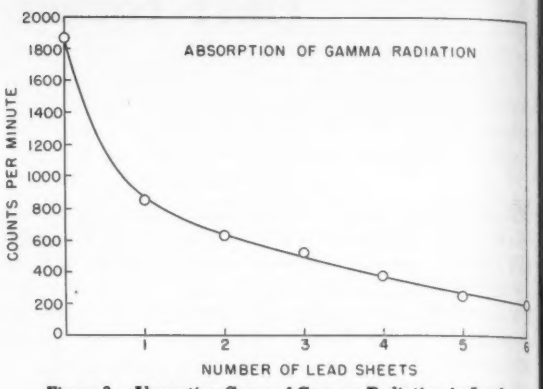

Figure 3. Absorption Curve of Gamma Radiation in Lead

Absorption of Gamma Radiation by Lead. The absorption of gamma radiation depends not only upon the mass (absorber thickness in mg./cm.^{2}) through which it passes but also upon the atomic number of the absorbing material. The effect of absorber thickness may be determined in the following manner. A one-microcurie sample of Co^{60}, a gamma source, is mounted on a small wooden block and placed 2 in. from the Geiger tube. Readings of counts per minute are taken as $^1/_8$ in. sheets of lead are placed between the sample and the detector. A graph of the data (Figure 3) roughly illustrates the large mass of material necessary to absorb gamma radiation. The exponential character of this absorption is more clearly shown if a graph of the logarithm of counts per minute versus the thickness of lead is constructed.

The students are encouraged to observe the effect of the lead shielding on beta radiation and the relatively poor usefulness of aluminum as an absorber for gamma radiation.

Effect of Distance on Intensity of Radiation. The intensity of electromagnetic radiation varies inversely as the square of the distance from the source, and this may readily be demonstrated to hold for gamma radiation. The gamma source is first placed 4 cm. from the Geiger tube and the intensity of radiation determined. The sample is then moved to a distance of 40 cm. from the tube and the counts per minute redetermined. Since the ratio of distances is 1:10, the intensity of radiation falls to approximately .01 of its original value.

THE SEPARATION OF THORIUM FROM URANIUM

Uranium 238 emits an alpha particle and produces thorium 234. The latter is a relatively short-lived beta emitter. Due to the differences in chemical properties of the two, thorium may be separated from an aged uranium sample by precipitation with ferric hydroxide as carrier.

One gram of uranyl sulfate is supplied to each student and the activity of the sample first checked by means

of the Geiger counter. The uranyl sulfate then is dissolved in 10 ml. of water and three drops of 0.1 *M* ferric chloride solution added. The solution is made basic by the addition of 2 ml. of ammonia water and solid potassium carbonate added until the bright yellow precipitate just disappears. The small amount of ferric hydroxide with coprecipitated thorium hydroxide remains in suspension. The mixture is filtered through a small circle of filter paper with the aid of a suction filter, and the activity of the precipitate tested by means of the Geiger counter. The intense activity of the sample may be shown to be due primarily to beta emission by use of the aluminum and lead sheets as absorbers.

Crystalline uranyl acetate is recovered from the above filtrate by the addition of solid potassium acetate. These crystals are collected and found to possess little of the activity shown by the original uranium sample.

THE HALF-LIFE OF IODINE 128

The half-life is an important and distinctive property of unstable nuclei. The students' inability to comprehend and understand this phenomenon is largely overcome by letting them carry out measurements of the half-life of an isotope for themselves. Iodine 128 is convenient for this purpose because it has a half-life of 25 minutes and because it may readily be synthesized by the action of neutrons on iodine 127, the equation being

$$_{53}I^{127} + {}_{0}n^{1} \rightarrow {}_{53}I^{128} + \gamma$$

The resulting iodine 128 is beta active, decaying to stable xenon.

A sealed nickel capsule containing 5 mg. of radium mixed with 50 mg. of beryllium serves as a source of neutrons. Such sources may be obtained from the Canadian Radium and Uranium Corporation and from a number of other suppliers. *Warning:* It has been reported that often a newly purchased source arrives in a hazardous condition due either to contamination during manufacture or to breakage. Each shipment should be carefully monitored as it is unpacked in order to determine the condition of the source.

The radioactive iodine is prepared each day before use in the manner described by Williams, *et al.* (ref. 3) The neutron source is placed in a spherical one-liter flask containing ethyl iodide and a small amount of free iodine. In the Szilard-Chalmers reaction that takes place, the slow neutron bombardment of the iodine in ethyl iodide produces some I^{128}. The recoil from the gamma emission of I^{128} ruptures the iodine-carbon bonds, and the major proportion of the active iodine appears as free iodine. When the concentration of active iodine is sufficient (after three or four times the half-life of the isotope, or even better overnight) the free iodine is extracted with 5 ml. of a 10 per cent solution of sodium hydroxide and is converted to silver iodide. The active silver iodide is collected in several portions on filter paper and is given immediately to the students. Each sample is mounted on a wooden block by means of Scotch tape, and the sample is placed directly in front of the Geiger tube. Counts per minute are recorded at three-minute intervals, and a plot of counts per minute versus time is constructed. Figure 4 illustrates the

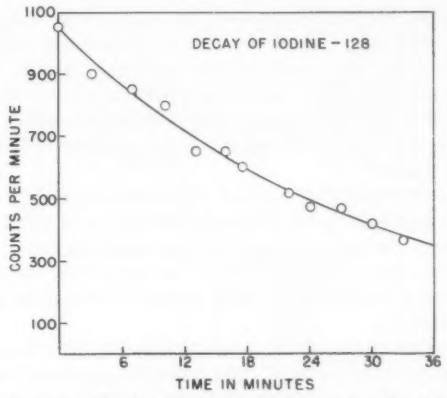

Figure 4. Typical Student Result of the Determination of the Half-life of Iodine 128

results obtained by one student. The half-life is found by reference to the graph. In this case the time interval necessary for the activity to decrease to one-half any particular value is about 23 minutes, a result quite satisfactory considering the methods and apparatus in use.

CONCLUSION

The use of appropriate questions with this experiment provides a way of tying together some of the essential points to be emphasized. We believe that it is quite desirable that the students appreciate the effects of distance, of shielding, and of the penetration of the different types of radiations since these are problems inherent in the use of atomic energy. The recent government pamphlets on protection from atomic bomb attacks are largely explained and more adequately understood in terms of some of the simple experiments described above.

Although the initial cost of preparing such a laboratory exercise may be prohibitive in some cases, it should be pointed out that the same Geiger counters and sources could be used to present a variety of experiments suitable for a course in physical chemistry. In addition to this, the number of instruments need not be large for an introductory course. Only 12 sets of equipment were necessary for the instruction of more than 400 students, a maximum of 90 students being present at any particular laboratory session.

ACKNOWLEDGMENT

The authors are indebted to Dr. M. Kent Wilson for many suggestions and for his interest in the development of the experiments.

THE HISTORY OF BARBITURIC ACID

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BARBITURIC acid, prepared by Adolf von Baeyer in 1864, was only one of the many compounds which resulted from the work on the uric acid group. This compound probably is as important as any of the uric acid derivatives as a result of its introduction into medicine in the form of the barbiturates, a group of the hypnotic drugs.

The work in the field of the uric acid group began with the well-known discovery of uric acid in 1776 by Scheele. Scheele noticed in his subsequent work on uric acid that when it dissolved in nitric acid a colorless solution formed which when applied to the skin gave a red color (*1*).

The presence of the urea residue in uric acid was shown by Fourcroy[1] in 1802 when he obtained urea by treating uric acid with chlorine water (*2*). In 1818 Gasparo Brugnatelli found on repeating the experiment of Scheele that uric acid mixed with nitric acid reacted in the presence of chlorine water to form a substance which he isolated. He named this substance *erythric acid* from the Greek word meaning to redden since it turned red when heated (*3*). This substance was later renamed *alloxan* by Liebig and Wöhler since, according to them, it contained the constituent residues of allantoin and oxalic acid (*4*). Previous to the work of Liebig and Wöhler, Prout had obtained erythric acid by the oxidation of murexide (ammonium purpurate) with nitric acid. He obtained the murexide by reacting a mixture of uric acid and nitric acid with ammonia (*5*, *6*). Both of these compounds, urea and alloxan, were later used in the preparation and synthesis of barbituric acid.

Liebig and Wöhler published their classical work on uric acid in 1838 (*4*, *7*). They found that oxidation of uric acid with dilute nitric acid gave another compound, known today as alloxantin, a condensation product of alloxan with dialuric acid. The reduction of alloxan to give alloxantin and the oxidation of alloxantin to give alloxan were clearly shown by these two men.

Adolph Schlieper, a student of Liebig's, also worked on alloxan. In 1845 he published two papers on his work in which he had obtained hydurilic acid in attempting to prepare alloxan, and he also obtained dilituric acid by oxidizing alloxantin (*8*). These two last mentioned compounds were used specifically later on by Baeyer in preparing barbituric acid. In the winter of 1858–59, when Baeyer was going from Heidelberg to Ghent where he was to rejoin Kekulé, he made the acquaintance of Schlieper, who was then a manufacturer in Elberfeld where Baeyer's sister lived (*9*, *10*). Schlieper had saved the uric acid compounds on which he had worked and he now gave these to Baeyer for further investigation. Even though Baeyer remained at Ghent only a year his investigations there led to the discovery of pseudo-uric acid which he published in collaboration with Schlieper (*11*). Later, Baeyer's famous student, Emil Fischer, worked out a synthesis for uric acid by the elimination of water from pseudo-uric acid (*12*). Most of Baeyer's work on the uric acid group was done during the period from 1860 to 1872 while he was in Berlin. Baeyer found that the oxidation of hydurilic acid gave violuric acid, which on further oxidation gave dilituric acid. He worked out the relations among these various compounds and came to the conclusion that they were all related, and that they originated from barbituric acid. Following is a list of the more important uric acid derivatives of the alloxan group as given by Baeyer (*13*):

Related Compounds Between Barbituric Acid and Uric Acid

$N_2C_4O_3H_4$	Barbituric acid
$N_2C_4O_3BrH_3$	Bromobarbituric acid
$N_2C_4O_3Br_2H_2$	Bibromobarbituric acid
$N_2C_4O_3(HO)H_2$	Dialuric acid
$N_2C_4O_3(HO)_2H_2$	Alloxan
$N_2C_4O_3(NO)H_3$	Violuric acid
$N_2C_4O_3(NO_2)H_3$	Dilituric acid
$N_2C_4O_3(NH_2)H_3$	Uramil
$N_2C_4O_3(NH_2, CNHO)H_3$	Pseudo-uric acid
$N_2C_4O_3(NCNH)H_2$	Uric acid
Three of the alloxantin group	
$N_2C_4O_3(HO)_2H_2 + N_2C_4O_3(HO)H_3 - 2H_2O$	Alloxantin
$N_2C_4O_3(HO)H_3 + N_2C_4O_3H_4 - H_2O$	Hydurilic acid
$N_2C_4O_3(NO)H_3 + N_2C_4O_3(NO_2)H_3$	Violantin

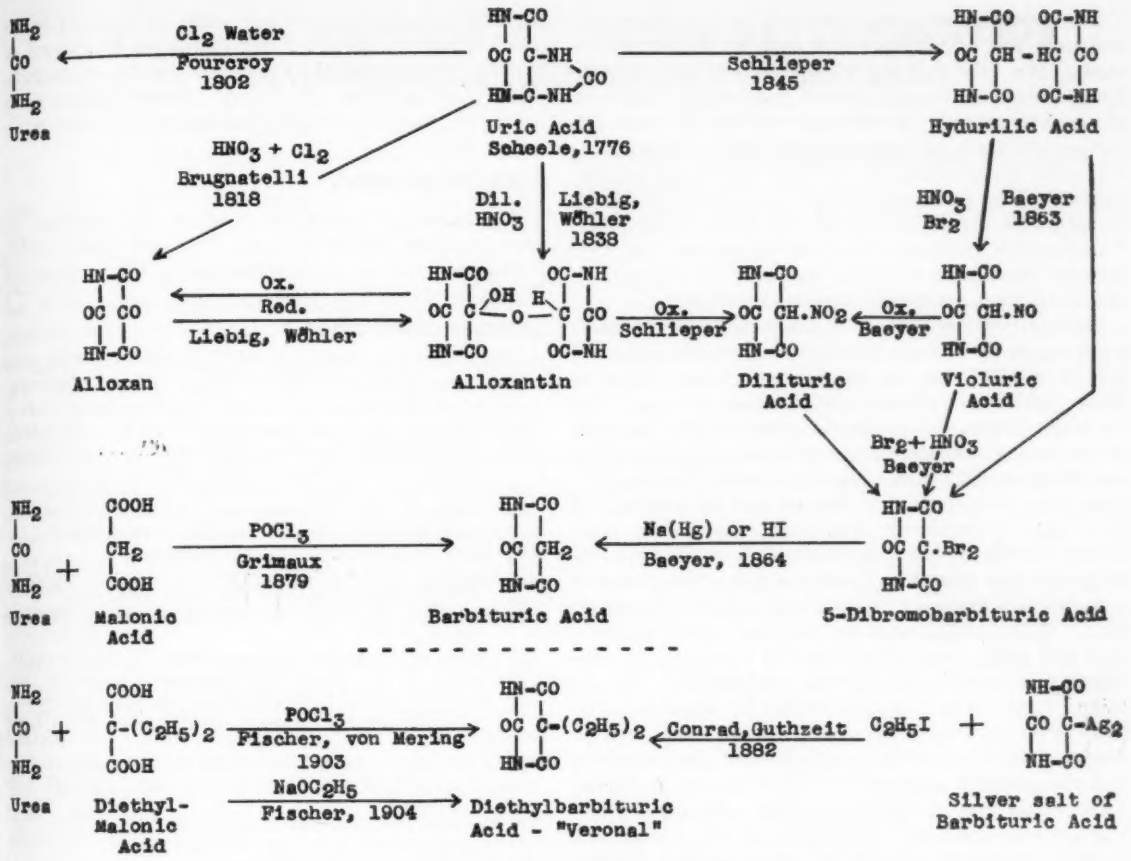
In order to substantiate the hypothesis that barbituric acid was the beginning compound Baeyer prepared it. By the reaction of bromine on violuric acid, dilituric acid, or hydurilic acid he obtained alloxanbromide. The equation given by him for the reaction with the use of hydurilic acid is as follows (*13*):

$$N_4C_8O_6H_6 + H_2O + 3Br_2 \rightarrow N_2C_4O_3Br_2H_2 + N_2C_4O_4H_2 + 4HBr$$

Hydurilic acid — Alloxanbromide — Alloxan

Baeyer then worked out a better procedure for the preparation of alloxanbromide, or dibromobarbituric acid, which consisted in heating a mixture of hydurilic acid and nitric acid saturated with bromine until the crystals formed dissolved with the liberation of nitrous acid. On cooling, the alloxanbromide crystallized out (*13*). From dibromobarbituric acid Baeyer then pre-

[1] Fourcroy assigned the name uric acid to the substance discovered by Scheele. It had previously been called bezoardic or lithic acid.

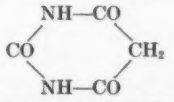


Outline of the History of Barbituric Acid

pared barbituric acid (*14*). His procedure consisted in mixing the dibromobarbituric acid in small portions with sodium amalgam covered with a little water. Crystals of monobromobarbituric acid crystallized out with the liberation of heat. By long treatment with excess amalgam the monobromobarbituric acid was converted into barbituric acid sodium. This salt was then dissolved in water, neutralized with acetic acid and then treated with strong hydrochloric acid. The barbituric acid formed separated out in small prisms or leafy crystals. Since it was hard to prevent a simultaneous reaction with the formation of bromoform, Baeyer found it better to use hydrogen iodide in place of sodium amalgam. About 50 g. of dibromobarbituric acid was mixed with 100 g. of hydrogen iodide and was warmed on the water bath for fifteen minutes. This liquid was diluted with an equal quantity of water and the iodine which separated was filtered off. On cooling after evaporation the barbituric acid crystallized out. It is curious that Baeyer did not attempt a synthesis of barbituric acid, as he knew that the two main constituent residues were urea and malonic acid (*15*).

Several stories have been given for the naming of malonylurea by Baeyer as barbituric acid.[2] The one given by W. A. T. Cohen-DeMeester was obtained from Professor Kögel, a student of Willstätter, who in turn was a student and friend of Baeyer (*16*). It seems that when Baeyer prepared malonylurea he was "charmed by a youthful beauty Barbara X" whose name he incorporated with the letters "ur" to designate the derivation of the acid from urea.

It was not until 1873 that the correct structural formula for barbituric acid was given by Mulder (*17*). In his elucidation of the structures of other related compounds he states that the structure of barbituric acid is:



[2] The story given by Professor James Kendall in J. CHEM. EDUC., 23, 2 (1946) does not fit chronologically. Professor Kendall makes the assumption that Baeyer discovered barbituric acid while at Ghent. Baeyer left Ghent in 1860 and his first paper on barbituric acid did not come out until 1863. Not until 1864 did his paper on the preparation of barbituric acid appear. He published in 1860 his work on pseudo-uric acid with Schlieper and it is unlikely that he had prepared barbituric acid by this time, otherwise this work would have been published also.

The synthesis of barbituric acid from malonic acid and urea was accomplished in 1879 by Édouard Grimaux (*18*). By heating on the water bath for two hours a mixture of equal parts of malonic acid and urea in the presence of phosphorous oxychloride and dissolving the resulting mixture in ten times as much boiling water he obtained on cooling a yellow flaky precipitate. The pure malonylurea was obtained by recrystallization of the precipitate from alcohol and water. Various other syntheses have been worked out but they are only modifications of the one used by Grimaux in which different condensing agents are utilized.

During the latter part of the nineteenth century much work was done on drugs which were hypnotic in nature. Joseph von Mering at the Clinical Laboratories in Halle continued earlier work on this class of drugs. His work led eventually to the discovery of the hypnotic properties of diethylbarbituric acid. It should be noted that in 1882 Max Conrad and Max Guthzeit prepared this derivative of barbituric acid by heating the silver salt of barbituric acid with ethyl iodide (*19*). When von Mering began anew his work on the hypnotic drugs he knew from his experience that ethyl groups in suitable combination with urea had hypnotic properties (*20*). With this in mind he combined diethylmalonic acid and urea, using the method of Grimaux, by condensing them with phosphorous oxychloride. He obtained a crystalline compound which he presumed to be diethylmalonylurea. Since von Mering was not an expert in determining the constitution of compounds he had the product analyzed by Emil Fischer in Berlin. Fischer and von Mering had known each other when Fischer was a student at Strassburg (*21*). Fischer's analysis confirmed von Mering's supposition. Fischer later published a method of preparing diethylbarbituric acid using sodium ethoxide as a condensing agent (*22*). This is the method most commonly thought of when one considers the preparation of this and similar compounds. The name "Veronal" given to this compound by von Mering was suggested to him as he approached Verona while on a trip through Italy (*23*). He seems to have had a fondness for inventing striking names such as this.

Since the publication of Fischer and von Mering on the hypnotic properties of diethylbarbituric acid (*24*) literally thousands of barbituric acid derivatives have been prepared and their hypnotic value tested. It has been found that to be effective both hydrogen atoms in the fifth place of the molecule must be replaced by an alkyl or aryl group (*25*). By increasing the length of the alkyl chain, differences in potency of the compounds, usually an increase, are found. Other differences in action are found by varying the chains by branching or unsaturation.

ACKNOWLEDGMENT

The author, a graduate student and assistant in pharmacology, wishes to thank Professor Clara deMilt for her suggestions and helpfulness in the preparation of this paper.

LITERATURE CITED

(1) Scheele, Karl Wilhelm, Opuscula II, 73–9. Cited by P. A. Levene and L. W. Bass, "Nucleic Acids," The Chemical Catalogue Co., Inc., New York, **1931**, p. 76.
(2) Fourcroy, A. F. de, *Annales du Museum*, **1**, 98 (1802). Cited by Emil Fischer, "Untersuchungen in der Puringruppe," Julius Springer, Berlin, **1907**, p. 4.
(3) Brugnatelli, Gasparo, *Phil. Mag.*, **52**, 30–47 (1818).
(4) Wöhler, F., and J. Liebig, *Ann.*, **26**, 241–340 (1838).
(5) Prout, W., *Trans. Roy. Soc.* (London), **1818**, 420–8.
(6) Prout, W., *Ann. Phil.*, **14**, 363–4 (1818).
(7) Lachman, Arthur, "The Spirit of Organic Chemistry," The Macmillan Co., Inc., New York, **1904**, p. 93.
(8) Schlieper, Adolph, *Ann.*, **55**, 251–97 (1845); **56**, 1–29 (1845).
(9) Henrich, Ferdinand, J. Chem. Educ., **7**, 1231–48 (1930).
(10) Perkin, W. H., "The Baeyer Memorial Lecture," in "Memorial Lectures Delivered Before the Chemical Society, 1914–32," Burlington House, London, **1933**, Vol. III, pp. 47–73.
(11) Schlieper, A., and A. Baeyer, *Bull. acad. roy. méd. Belg.* [2], **9**, No. 2. Cited by Adolf Baeyer, *Ann.*, **127**, 1–27 (1863), p. 3.
(12) Fischer, Emil, *Ber.*, **30**, 2226–54 (1897).
(13) Baeyer, Adolf, *Ann.*, **127**, 199–236 (1863).
(14) Baeyer, Adolf, *ibid.*, **130**, 129–75 (1864).
(15) Baeyer, Adolf, *ibid.*, **131**, 291–302 (1864).
(16) Cohen-DeMeester, W. A. T., *Chem. Weekblad*, **40**, 176–9 (1943).
(17) Mulder, E., *Ber.*, **6**, 1233–7 (1873).
(18) Grimaux, Édouard, *Bull. soc. chim. Paris* [2], **31**, 146–9 (1879).
(19) Conrad, M., and M. Guthzeit, *Ber.*, **15**, 2844–50 (1882).
(20) Hoesch, Kurt, "Emil Fischer, Sein Leben und Sein Werk," Berlin, **1921**, pp. 240–5.
(21) Fischer, Emil, "Aus Meinem Leben," Julius Springer, Berlin, **1922**, p. 55.
(22) Fischer, Emil, and Alfred Dilthey, *Ann.*, **335**, 334–68 (1904).
(23) Zuntz, N., *Münch. med. Wochschr.*, **55**, 400–2 (1908).
(24) Fischer, Emil, and J. von Mering, *Therap. Gegenwart*, **44**, 97–101 (1903).
(25) Tatum, A. L., *Physiol. Revs.*, **19**, 472–502 (1939).

AN EXPERIMENT ON THE DETERMINATION OF FORMAL OXIDATION POTENTIALS

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G. H. WALDEN, L. P. Hammett, and R. P. Chapman[1] made a study of the ferrous-orthophenanthroline complex (Ferroin) and developed it as an oxidation-reduction indicator with a formal oxidation potential of 1.14 volts. D. N. Hume and I. M. Kolthoff,[2] taking the formal potential of the ferrous-ferric couple in one molar sulfuric acid to be 0.68 volt, re-evaluated the formal potential of the indicator at 1.06 volts.

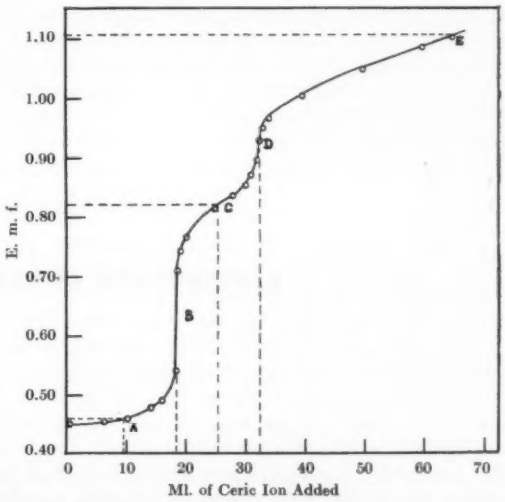
Other workers[3, 4] have studied the effects of different acids employed at different strengths upon the formal potentials of the ferrous-ferric and the ceric-cerous systems as well as the effects of various sulfuric acid strengths upon the formal potentials of Ferroin and substituted Ferroins.

The experimental procedures in the above cited articles are in general too involved to be employed in a laboratory experiment. However, with certain simplifications the study of the formal potentials of these couples can be made the basis of an excellent experiment that can be easily completed in one laboratory period. Good agreement with the accepted values can be obtained.

EXPERIMENTAL

Equimolar amounts of ferrous ions and ferrous-orthophenanthroline complex in 1 *M* sulfuric acid were prepared by dissolving 0.12 g. of reagent-grade $FeSO_4 \cdot 7H_2O$ and 0.12 g. of orthophenanthroline monohydrate in 180 ml. of distilled water. Eleven ml. of concentrated sulfuric acid were added and the total volume of the solution brought to 200 ml. The solution was immediately titrated potentiometrically with 0.01 *M* ceric ion in 1 *M* sulfuric acid (prepared by dissolving 3.06 g. ceric ammonium sulfate in 500.0 ml. 1 *M* H_2SO_4). Potentiometric measurements were made with a type K1 potentiometer, although other types would be satisfactory. A Fisher pointer-type d.-c. galvanometer with a sensitivity of 0.1 microampere per millimeter was used. Reference electrodes used were saturated calomel or quinhydrone (in 1 *M* H_2SO_4, Au). The indicator electrodes were gold or platinum. Any combination of these will yield good results.

A convenient quinhydrone reference electrode can be prepared by placing a freshly prepared saturated solution of quinhydrone in 1 *M* sulfuric acid in a salt-bridge tube of the immersion-type calomel electrode. This eliminates the need of a connecting salt bridge. The dip-type quinhydrone electrode is immersed in the solution. Since the sulfuric acid concentration does not change during the course of this titration the potential of this electrode is constant.



Titration of an Equimolar Solution of Ferrous Sulfate and Ferrous Phenanthroline Sulfate in 1 *M* Sulfuric Acid with 0.01 *M* Ceric Sulfate in 1 *M* Sulfuric Acid, Using a Saturated Calomel Electrode for Reference and a Pt Electrode as Indicator

A typical curve obtained by the simplified procedure is shown in the figure. When the quinhydrone electrode is used for a reference, the results are interpreted as in the original article (ref. 1). When the saturated calomel electrode of known potential is used, the formal potentials of the ferric-ferrous, ferric-ferrous orthophenanthroline, and the ceric-cerous electrodes may be calculated from the observed potentials at the points A, C, and E on the titration curve. These points correspond to the potential observed when the ratio of the concentration of the oxidized and reduced forms in the respective couples is unity.

The formal potentials are calculated as follows:

$$E_{obs.} = E_{s.c.e.} + E_{cathode}$$
$$E_{cathode} = E_{obs.} + 0.2438$$

[1] WALDEN, G. H., L. P. HAMMETT, AND R. P. CHAPMAN, *J. Am. Chem. Soc.*, **55**, 2649 (1933).
[2] HUME, D. N., AND I. M. KOLTHOFF, *J. Am. Chem. Soc.*, **65**, 1895 (1943).
[3] SMITH, G. F., AND C. A. GETZ, *Ind. Eng. Chem., Anal. Ed.*, **10**, 191 (1938).
[4] SMITH, G. F., AND F. P. RICHTER, *Ind. Eng. Chem., Anal. Ed.*, **16**, 580 (1944).

Electrodes used			Formal potential (in 1 M H_2SO_4), volts	
Ref.	Ind.	Couple	Experimental	Accepted
s.c.e.	Pt	Fe^{++}, Fe^{+++}	0.69	0.68
		FeR_3^{++}, FeR_3^{+++}	1.06	1.06
		Ce^{+++}, Ce^{++++}	1.36	1.44
s.c.e.	Au	Fe^{++}, Fe^{+++}	0.68	0.68
		FeR_3^{++}, FeR_3^{+++}	1.06	1.06
		Ce^{+++}, Ce^{++++}	1.39	1.44
H_2Q	Pt	FeR_3^{++}, FeR_3^{+++}	1.04	1.06
H_2Q	Au	FeR_3^{++}, FeR_3^{+++}	1.03	1.06

In the original procedure, it was necessary to reduce the iron completely to the ferrous state before starting the titration in order that point A (from which the value of point C is calculated) might be determined accurately. With a reference electrode of known potential point C can be calculated, as long as enough ferrous ions are present to permit the accurate determination of end point B.

Experimental results for various electrode combinations are shown in the table.

As can be seen, the formal potential of the ferric-ferrous couple (point A) can be determined with reasonable accuracy even without preliminary reduction procedures if the solutions are prepared from reagent grade material immediately before titration. With a standard reference electrode, the accuracy with which the complex potential is determined is not dependent upon the preliminary reduction to ferrous ions. This suggests that the simplified procedure might be used for the development of other oxidation-reduction indicators.

One precaution is to be observed in the preparation of the solution for titration. The ferrous-orthophenanthroline complex must be formed in the absence of any sulfuric acid. If the reagents are dissolved directly in 1 *M* sulfuric acid only one break will be observed in the titration curve. This break corresponds to the oxidation of the ferrous ions to the ferric state.

SUPPORT FOR COMPRESSED GAS CYLINDERS

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Diamond Research Laboratory, Johannesburg, South Africa

MOST compressed gas cylinders are awkward objects around a laboratory or lecture room. Unless placed in a fitted recess in a bench or corner, their shape renders them unstable when upright and consequently in constant danger of being knocked over during cleaning of benches and floors or even during normal chemical operations in a crowded laboratory. The usual tall, flat-bottomed cylinder is bad enough in this respect, but many gas cylinders are round-bottomed, which of course greatly increases their instability. Cylinders for plant purposes are sometimes mounted on a small, rubber-tired cart, but the bulk of this assembly renders it unsuitable for laboratory use.

An obvious way to overcome this difficulty is to strap the cylinder to a fixed point on a bench or wall. This entails screwing or bolting two metal swivels, to which are attached the ends of a belt or webbed strap into the side of a bench or wall. This is satisfactory for some routine operations where the position of a gas cylinder is permanent, but in a research laboratory cylinders are frequently moved to different parts of the building. Likewise, in a lecture room it is necessary to move cylinders to different positions along the demonstration bench.

We have found that rubber suction discs, commonly used on the top of automobiles for supporting a light framework designed to carry a load on the roof of a car, can be employed as a support for gas cylinders. These discs are usually about 3 in. in diameter and are provided with a screwed bolt in the center. A metal swivel to which is rivetted the strap of leather or webbing can thus be easily attached to the rubber disc. These rubber suction discs will adhere very satisfactorily for long periods to a smooth surface of metal, tile, cement, or wood. If the surface is not fairly smooth it is advisable to smear on a little glycerol or vaseline before pressing the rubber onto it. Two stout pieces of webbing, one of which is provided with a buckle, fastened by swivels to two rubber discs, thus form an efficient, flexible, and unobtrusive means of supporting gas cylinders in perfect safety in almost any part of the laboratory where they may be needed.

RECENT ADVANCES IN THE CHEMISTRY OF ZIRCONIUM AND HAFNIUM[1]

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The University of Wisconsin, Madison, Wisconsin

THE recent announcement (*1*) that high-purity hafnium metal has been produced in pound quantities at the Y-12 laboratories of the Oak Ridge National Laboratory dramatizes the advances made in this field during the past five years. The slow progress up to now in the development of the chemistry of element 72 is directly related to the very small supply of the purified element that has been available. This scarcity is not due to its low abundance in the earth's crust, for it occurs in igneous rock to about the same extent as tin, molybdenum, and arsenic, although not concentrated in specific ores; but rather due to the lack of a convenient and efficient process for separating hafnium from its chemical twin, zirconium. The extreme similarity in the chemical properties of these two elements is underlined by the fact that hafnium was discovered 133 years after the discovery of zirconium by Kalproth in 1789, even though, as we now know, hafnium is always associated with zirconium ores. This similarity in chemical behavior is related to the electron configuration of the valence electrons, $4d^2 5s^2$, $5d^2 6s^2$ for zirconium and hafnium respectively; and the similarity in ionic radii of the M^{+4} ions, Zr^{+4}, 0.74 Å., and Hf^{+4}, 0.75 Å. (*2*). The fact that the hafnium ion is almost the same size as the zirconium ion, although the nucleus of the former has 32 additional protons, is of course a consequence of the lanthanide contraction.

The production of hafnium probably would have remained at a very low level simply because there was little demand for it at the prices quoted, and because there appeared to be no necessity for developing an efficient process for removing it from zirconium. However, in 1949, Sumner Pike, then a member of the Atomic Energy Commission, in a speech before the North Jersey Section of the American Chemical Society in January (*3*), revealed a good reason for the production of hafnium-free zirconium. Mr. Pike discussed the problem of choosing construction and operating materials for the nuclear installations of the future and pointed out "that among the metals titanium has been found to be capable of withstanding the temperatures that are involved but that it absorbs neutrons badly. Zirconium holds promise, but means must be found to separate it from its annoying first cousin hafnium." A glance at the nuclear cross sections for the naturally occurring elements (Table 1) reveals the reason for the necessity of eliminating the hafnium from the zirconium, for hafnium has a cross-section capture for thermal neutrons several hundred times greater than that of zirconium.

[1] Presented before the Chemistry Section of the A.A.A.S., Cleveland, Ohio, December 29, 1950.

TABLE 1
Cross-section Capture for Thermal Neutrons for the Natural Element (*4*, *5*)

	Cm.²/atom × 10^{24}
Ti	5.8, 5.9
Zr	0.22, 0.4
Hf	103, 157

Recent methods of separating zirconium and hafnium in aqueous solutions have been successful; in part, due to a better understanding of the zirconium and hafnium solution chemistry. Unusual features of the aqueous chemistry of these elements are the high degree of hydrolysis exhibited, the formation of polymeric species, and the multitude of complex ions that can be formed.

AQUEOUS CHEMISTRY

The tetrahalogenides when placed in water react vigorously to give strongly acidic solutions. Even a 0.05 *M* solution of an oxysalt, such as $MOCl_2 \cdot 8H_2O$, will give a solution with a pH of about 1. It is difficult to reconcile these observations with the cryoscopic and conductometric data on the assumption that the generally accepted MO^{++} ion alone exists in solution.

The most definitive work on the nature of the ionic species in solution is that by Connick and McVey (*6*). The authors used the two-phase distribution system with a β diketone, thenoyl trifluoroacetone, in a benzene phase to study the equilibrium represented in the following equation:

$$Zr(IV) + 4HK \rightleftharpoons ZrK_4 + 4H^+ \qquad (1)$$

or in terms of the equilibrium constant

$$K_0 = \frac{[ZrK_4]_b (H^+)^4}{(Zr(IV))[HK]_b^4} \qquad (2)$$

which at constant hydrogen ion concentration may be expressed in terms of logarithms as

$$\log K_1 = \log E - 4 \log HK \qquad (3)$$

where

$$E = [ZrK_4]_b/(Zr(IV)) \qquad (4)$$

Here the β diketone HK and the resulting chelate ZrK_4 are in the benzene phase, while the remaining species are in the aqueous phase. The metal distribution was usually determined radiometrically using 65-day Zr^{95}, or in macro amounts by means of the zirconium lake

developed with alizarin. The free diketone at equilibrium was calculated from a knowledge of the quantity of chelate extracted into the benzene phase and the distribution coefficient of the diketone. For purposes of calculating the extraction coefficient and equilibrium constants, the activities of the species in the benzene were used, and the concentrations of the species in the aqueous phase. The activity coefficients of thenoyl trifluoroacetylacetone have been determined by King and Reas (7), and it was assumed that the activity coefficients for the chelate and diketone were essentially the same over the range of concentrations used. In the aqueous phase the ionic strength was maintained constant at 2 by the addition of $LiClO_4$ when necessary, and under these conditions it was assumed that the activity coefficients of the aqueous species remained constant.

Proof of the validity of equation (1) was obtained when the distribution coefficient was shown to have a fourth power dependence on the diketone concentration at constant hydrogen ion concentration. These data proved that the species in the benzene phase was ZrK_4 and not a hydroxylated molecule, that no complexing by the diketone occurred in the aqueous phase, and that the metal ion in the aqueous phase was a monomer.

COMPLEX ION FORMATION

To study the various species occurring in the aqueous phase, a second equilibrium reaction was imposed upon the first. This is represented as in equation (5):

$$\mathrm{Zr(IV)} + n\mathrm{HX}^{+(1-z)} \rightleftharpoons \mathrm{Zr(X)}_n^{+(4-zn)} + n\mathrm{H}^+ \qquad (5)$$

Here z is the charge on X and X in these studies was OH^-, F^-, or $SO_4^=$. The equilibrium constant for this reaction is:

$$K_6 = \frac{(\mathrm{Zr(X)}_n^{+(4-zn)})(\mathrm{H}^+)^n}{(\mathrm{Zr(IV)})(\mathrm{HX}^{+(1-z)})^n} \qquad (6)$$

To interpret the data quantitatively, the extraction coefficient expressed more generally as $E = [ZrK_4]/\Sigma_n\ ZrX_n^{+(4-zn)}$ was written in terms of the equilibrium constants K_0 and K_6.

$$E = \frac{[\mathrm{ZrK_4}]}{\sum_n K_6/_0[\mathrm{ZrK_4}](\mathrm{H}^+)^{4-n}(\mathrm{HX}^{+(1-z)})^n}{[\mathrm{HK}]^4}$$

$$\ln E = \frac{-\sum_n K_6/_0(\mathrm{H}^+)^{4-n}(\mathrm{HX}^{+(1-z)})^n}{[\mathrm{HK}]^4} \qquad (7)$$

To arrive at the number of hydroxyls per zirconium the extraction coefficient was studied as a function of the hydrogen ion concentration at constant HK activity. In this system $HX^{+(1-z)}$ then became H_2O. The expression obtained by carrying out the differentiation indicated and substituting $ZrX_n^{+(4-zn)}$ for its equivalent in the numerator and denominator is

$$\frac{\partial \ln E}{\partial \ln \mathrm{H}^+} = -4 + \frac{\sum_n n\mathrm{ZrX}_n^{+(4-zn)}}{\sum_n \mathrm{ZrX}_n^{+(4-zn)}}$$

$$= -4 + f_1 + 2f_2 + 3f_3 + \ldots \qquad (8)$$

Here f is equal to the fraction of total zirconium which has the number of hydroxyl groups per zirconium as indicated by the subscript.

To determine the degree of anion-cation interaction upon the addition of a foreign anion to the system, the extraction coefficient was studied as a function of the complexing ion concentration at constant hydrogen ion concentration and diketone activity. Equation (7) in this case was differentiated with respect to the $HX^{+(1-z)}$ concentration to give

$$\frac{\partial \ln E}{\partial \ln \mathrm{HX}^{+(1-z)}} = \frac{-\sum_n n\ \mathrm{ZrX}_n^{+(4-zn)}}{\sum_n \mathrm{ZrX}_n^{+(4-zn)}}$$

$$= -f_1 - 2f_2 - 3f_3 \qquad (9)$$

where f is equal to the fraction of the total zirconium which has the number of X groups per zirconium as indicated by the subscript. In all cases the measured extraction coefficients E were converted to the extraction coefficients one would have obtained at unit HK activity, $E°$, by using the fourth power dependence relationship of the E on the diketone concentration.

From a plot of the logarithm of $E°$ against the logarithm of the H^+ concentration, the average number of hydroxyls on the zirconium was determined from the slope of the line. Such a plot is shown in Figure 1A.

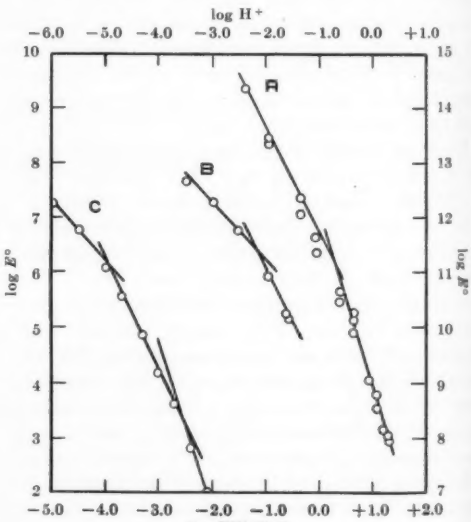

Figure 1

From this plot one can see that the number of hydroxyl groups increased as the hydrogen ion concentration decreased. Although the over-all path of the experimental points was decidedly curved, segments of the curve could be fitted to straight lines drawn with slopes of −2 and −3, respectively. The points at the highest acidity determined from solutions containing macro amounts of zirconium could fit a slope of −4, which would correspond to Zr^{+4} species. Later data by Connick and Reas (8) indicate that the important species in 2 N $HClO_4$ most probably is the nonhydroxylated

TABLE 2

$HX^{(z-1)}$ conc., g. ions/l.	Average number of X groups per zirconium	
	F^-	HSO_4^-
10^{-5}	1	<1
10^{-4}	2	<1
10^{-2}	3	1
0.2	3	2

TABLE 3

	F^-	SO_4^-
K_1	6.3×10^5	4.6×10^2
K_2	2.1×10^4	53
K_3	6.7×10^2	1

Zr^{+4}. Between 2 and 0.2 M, the slope is -3 indicating $Zr(OH)^{+3}$ as the average composition of the metal ion, and below 0.2 M the slope is -2, indicating $Zr(OH)^{+2}$. The equilibrium constant for the $Zr(OH)^{+3} + H_2O \rightleftharpoons Zr(OH)_2^{+2} + H^+$ reaction was found to be $K = 0.187$.

Plots of the logarithm of $E°$ against the logarithm of the complexing agent are given in Figures 1*B* and 1*C* for the hydrogen sulfate and fluoride ions respectively. Again the curvature of the line indicates the presence of a series of complex ions and from the slope of the line over a small range of $HX^{+(1-z)}$ concentrations the average number of X units per zirconium was calculated (Table 2). From these data it was apparent that the zirconium was much more strongly complexed by the fluoride than by the hydrogen sulfate ion.

The successive equilibrium constants for fluoride and sulfate complexing calculated by Connick and McVey using a modification of the method of Leden (*9*) are shown in Table 3 for the following reactions:

$$Zr^{+4} + X^{-z} \rightleftharpoons ZrX^{4-z} \quad K_1$$
$$ZrX^{4-z} + X^{-z} \rightleftharpoons ZrX^{4-2z} \quad K_2$$
$$ZrX^{4-2z} + X^{-z} \rightleftharpoons ZrX^{4-3z} \quad K_3$$

No data for hafnium are available except that from the extraction studies using trifluoroacetylacetone (*10*) which indicate that the hafnium-chloride complex may be stronger than the zirconium-chloride complex.

PRECIPITATION STUDIES

As the hydrogen ion concentration of zirconium and hafnium solutions is decreased these elements precipitate as hydrated oxides or hydroxides at pH's of a little over 2. Comparison of the data obtained by electrometric titrations (*11*) with that of Connick and McVey is not possible because the titrations were run at a much lower ionic strength and at higher metal ion concentrations. Data are available for both zirconium and hafnium in perchloric, nitric, and hydrochloric acid solutions. Typical titration curves are shown in Figure 2 with the points of initial precipitation and coagulation indicated by doubly and singly barbed arrows respectively. No inflection was observed at the point of precipitation, nor was there any evidence of resolution of the precipitate at higher pH's. Data for a series of titrations at different metal ion concentrations are given in Tables 4 and 5. The anion-cation ratio for these systems was 4.

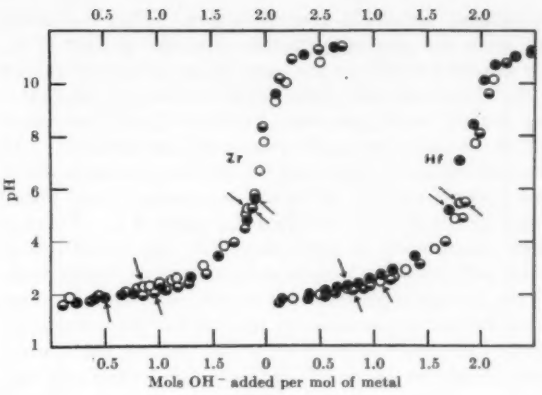

Figure 2

Several significant trends can be observed in these data. In all cases the hafnium solutions have a higher pH of precipitation than the zirconium solutions at

TABLE 4

pH of Precipitation and pK Data for Zirconium and Hafnium Hydroxides-Perchloric Acid Solutions

G. ions/l. × 10^3 at pptn.		$\sqrt{\mu}$ at pptn.	pH pptn.	R		pK
				Pptn.	Coag.	
Zr	Hf					
18.0		0.27	2.05	0.87	1.87	8.92
12.2		0.22	2.16	0.82	1.89	9.01
7.5		0.17	2.31	0.77	1.89	9.13
4.2		0.13	2.47	0.91	1.91	9.29
	18.6	0.27	2.13	0.80	1.96	8.85
	12.6	0.22	2.23	0.75	1.87	8.96
	7.6	0.17	2.38	0.75	1.86	9.09
	4.3	0.13	2.60	0.87	1.91	9.21

TABLE 5

pH of Precipitation Data for Zirconium and Hafnium Hydroxides—Chloride and Nitrate Solutions

Anion	G. ions/l. × 10^3 at pptn.		$\sqrt{\mu}$ at pptn.		pH pptn.		R			
							Pptn.		Coag.	
	Zr	Hf	Zr	Hf	Zr	Hf	Zr	Hf	Zr	Hf
Cl^-	20	19.1	0.28	0.27	1.88	2.34	0.50	0.73	1.88	1.70
	13.4	12.7	0.23	0.22	1.97	2.43	0.34	0.81	1.83	1.75
	7.9	7.7	0.17	0.17	2.14	2.49	0.23	0.76	1.94	1.82
	4.3	4.3	0.13	0.13	2.29	2.73	0.23	0.88	1.93	1.86
NO_3^-	17.2	17.8	0.27	0.27	2.34	2.47	0.85	1.07	1.83	1.80
	12.2	12.1	0.23	0.22	2.36	2.48	0.69	0.96	1.73	1.80
	7.6	7.4	0.18	0.18	2.39	2.57	0.36	0.86	1.86	1.86
	4.3	4.1	0.13	0.13	2.40	2.87	0.24	1.01	1.80	1.90

equivalent metal ion concentrations. This is consistent with the general principle that the acidity of an ion in solution follows the same order as the crystal ion sizes. Since the difference in size for the Zr^{+4} and Hf^{+4} ion is very small, one would expect the differences in pH of precipitation to be very small, as they are. All the precipitates coagulated before the ratio of mols of OH^- added to mols of metal ion present, here designated as the R value, reached the value of 2. This has been interpreted as signifying (*12*) the formation of basic salts with the hydroxyl ion deficiency being made up by the anion present. However, it would also seem possible that the extensively hydrolyzed species already present reacted further with water to form the neutral metal oxide or hydrated oxide and the hydronium ion, the latter then being titrated to the end point. The R value at which the initial precipitation was observed was constant within the accuracy of the experimental technique. This was taken as an indication that the composition of the precipitate was the same at all dilutions.

The behavior of zirconium and hafnium in chloride and nitrate solutions was significantly different (Table 5). The R values for precipitation decreased rapidly with dilution for the zirconium, but remained essentially constant for the hafnium. This may indicate that zirconium has a greater tendency to form insoluble basic salts in these solutions than does hafnium. In addition, the pH of precipitation values for both elements in these solutions differ considerably from the values in perchlorate solution. However, it is doubtful that these differences would be realized in mixed zirconium-hafnium solutions because of coprecipitation.

The titration procedure has been used for the determination of solubility products, although there is some question whether or not such systems are truly in equilibrium. Britton (*13*) has pointed out, however, that solubility products from such data are in good agreement with those obtained by other methods. Examples of the application of this method may be found in the work of Moeller and Kremers (*14, 15*) on the rare earths. To be applicable, one must assume that over the precipitation range the system is represented by the equation

$$M(OH)_x^{+(4-x)} + (4 - x)(OH^-) \rightleftharpoons \text{hydrated oxide} \quad (10)$$

Then the logarithm of the solubility product would be expressed as

$$\log K_{sp} = \log M(OH)_x^{+(4-x)} + (4 - x) \log OH^- \quad (11)$$

A plot of the logarithm of $M(OH)_x^{+(4-x)}$ against the logarithm of the hydroxyl ion should give a straight line of slope $(x-4)$ from which the charge on the metal ion can be evaluated. Such a plot for the perchloric acid solution data is shown in Figure 4. Equation (11) was found to be valid over three-fourths of the precipitation range, deviating appreciably from linearity as the coagulation point was approached. The slope of the linear portion of the curve was -0.6, thus making the average number of hydroxyls on the metal ion species 3.4 and the charge on the metal ion $+0.6$. This was interpreted to mean that a polymeric species existed in solution over three-fourths of the precipitation range with the average formula $(M(OH)_{3.4}^{+0.6})_n$. In the calculation of pK (Table 4) the value of 14 for pK_w at 25° was used. It can be seen that the solubility decreases with decreasing ionic strength of the solution as would be expected. The ionic strengths of the solutions were calculated on the basis of the $M(OH)_{3.4}^{+0.6}$ ion. The pK values for the hafnium compound in pure water should be something less than 9.21, and less than 9.29 for the zirconium.

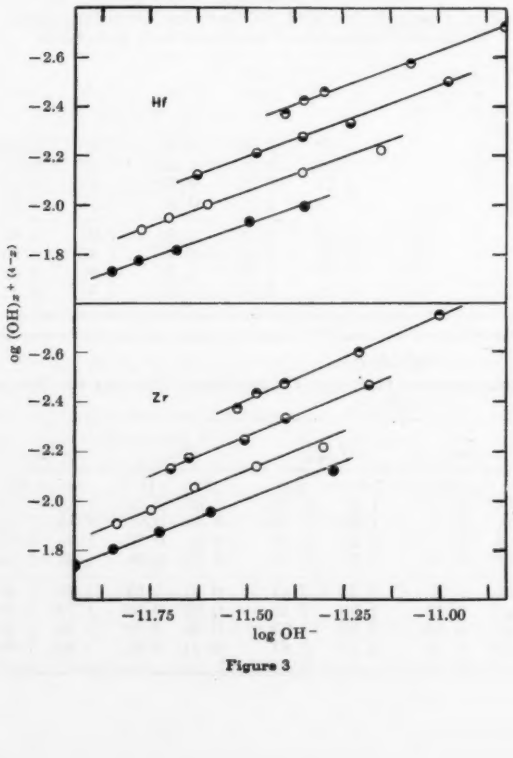

Figure 3

POLYMERIZATION STUDIES

The extraction coefficient as expressed in equation (3) should be independent of the metal ion concentration. However, it was observed that above certain metal ion concentrations the extraction coefficient was dependent on the concentration (*8, 10*); this requires the presence of polymeric metal ions, $Zr_x(OH)_n^{+4x-n}$ in solution. To study this phenomenon quantitatively Connick and Reas determined the variation in distribution coefficient E as a function of the zirconium ion concentration. In interpretation of the data, the polymerization reaction

$$xZr(IV) \rightleftharpoons Zr_x(IV) \quad (12)$$

must be considered in combination with equation (1). By expressing the extraction coefficient

$$E = \frac{[ZrK_4]_b}{\sum_{x=1} x(Zr)_x}$$

in terms of the equilibrium constant for equation (1)

at constant hydrogen ion and diketone concentrations, and $K_x = Zr_x/Zr^x$, one obtains

$$E = \frac{K_1'(Zr(IV))}{\Sigma x K_x (Zr)^x} \quad (13)$$

Converting to E° and carrying out the indicated differentiation, it can be shown that

$$\frac{\partial \ln E^\circ}{\partial \ln \Sigma x\, K_x (Zr)^x} = -1 + \frac{\Sigma x K_x (Zr)^x}{\Sigma x^2 K_x (Zr)^x}$$
$$\frac{\partial \ln E^\circ}{\partial \ln \Sigma x (Zr)_x} = -1 + \frac{1}{\Sigma x f_x} \quad (14)$$

Here f_x is the fraction of the total zirconium which exists in polymers containing x zirconium atoms. The average size of the polymer in which a zirconium ion occurs is given by $\Sigma x f_x$. The data for the variation in log E° with the log of the metal ion concentration fit the curves drawn in Figure 4 fairly well. The plateaus indicate that the concentration of polymers is zero, that is, only monomers exist in solution. This region is longer the higher the hydrogen ion concentration. At higher zirconium concentrations as the slope becomes negative the presence of polymers is indicated, with x becoming larger as the slope approaches the limit -1. The values for average degree of polymerization, $\Sigma x f_x$, at different metal concentrations calculated from the slope of the line and equation (15) are tabulated in Table 6.

TABLE 6

The Degree of Polymerization of Zirconium in Aqueous Perchloric Acid Solution

Log M^{+4} conc.	*Average degree of polymerization* 1 M H^+	2 M H^+	*Fraction of monomer* 1 M H^+	2 M H^+	*Number of Zr per polymer* 1 M H^+	2 M H^+
−4.00	1.15	...	0.90	...	2.6	...
−3.50	1.39	...	0.72	...	2.4	...
−3.00	2.12	1.16	0.45	0.86	3.0	2.2
−2.50	4.4	1.32	0.21	0.71	5.3	2.1
−2.00	9.0	2.06	0.082	0.47	10.0	3.0
−1.50	18.0	9.1	0.029	0.20	19.0	11.0

The fraction of the monomer present was calculated from the equation $f_1 = E^\circ/E_0^\circ$ where E_0° is the limiting value of E° at low zirconium concentration. These data show that the dimer makes an appreciable contribution to the ionic species in zirconium solution of 0.001 M.

From Figure 4 it can be seen that the two curves differ from one another at high zirconium concentrations to the extent of approximately 0.3 of a log unit. This would mean that the hydrogen ion dependence of the extraction coefficient would be related to polymeric species in which the zirconium to hydroxyl ion ratio was 1 to 3. It is interesting that these data indicate an average polymer composition similar to that arrived at from the electrometric titration data. However, it is not to be concluded that the nature of the polymer obtained as the hydrogen ion concentration is decreased is necessarily the same as the polymer obtained at high

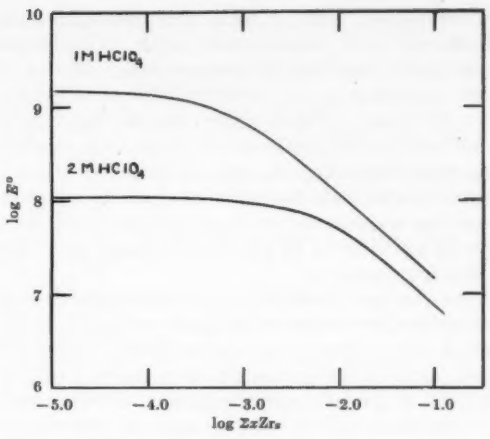

Figure 4

hydrogen ion concentrations when the metal ion is increased. It appears that in the latter case the reaction is easily reversible, for dilution of a concentrated stock solution immediately resulted in an increased extraction coefficient (*10*). However, even in the concentrated stock solutions at high hydrogen ion concentrations, upon long standing a nonextractable metal ion species appears. This nonextractable species is not easily reversible and behaves like the polymer obtained as the pH of the zirconium or hafnium solution is increased. The exact difference in the nature of these two polymers is not clear. They may represent two different chemically combined forms, or just a difference in the size of the polymer, with the reversible species containing a low number of metal atoms and the slowly reversible or irreversible containing a large number of metal atoms.

The relation of these data to the problem of achieving a separation of zirconium and hafnium in solution are obvious. The solutions must be dilute, below 0.001 M, freshly prepared, and at high hydrogen ion concentrations, to avoid polymer formations which will reduce the efficiency of the separation process. If polymers are formed in a zirconium-hafnium solution, there is no reason to believe that a mixed zirconium-hafnium polymer will not be formed, and under these conditions the efficiency of a separation would be still further reduced. It is also clear that the presence of foreign anions will reduce the extraction coefficient, but may improve the degree of separation owing to differences in the strength of anion-cation interaction.

METHODS OF SEPARATION

The methods used for the separation of hafnium from zirconium up to this time may be classified as follows: (1) the fractional crystallization of the hexafluorides (*16*), oxychlorides (*17*), or oxalates (*18*); (2) the fractional precipitation of the phosphates (*19*) or ethyl phosphates (*20*); (3) fractional distillation of $POCl_3$ addition compounds of MCl_4 (*21*); and (4) the fractional decomposition of complex ions of zirconium and

hafnium formed with sulfuric acid, phosphoric acid, hydrofluoric acid, dicarboxylic acids, α-hydroxycarboxylic acids, and polyhydroxyalcohols (*22*), to yield oxides, phosphates, or ferrocyanides as precipitates (*23*). All these processes suffer from the fact that they are not particularly applicable to large scale continuous production methods, although a modified phosphate precipitation method has been successfully adapted by at least one commercial producer (*24*) who has produced about 12 kg. of 98 to 99 per cent hafnium oxide during the past four years.

There does not appear to be any zirconium deposit in this country low enough in hafnium to make a hafnium removal step in the zirconium processing unnecessary. In fact, most of the normal zircon contains 1 to 2.5 per cent HfO_2 in the RO_2, and therefore a sizable reduction in the hafnium content must be made in order to make the zirconium satisfactory for use in a nuclear reactor.

RECENT PROCESSES

Solvent Extraction Processes. The first process to appear which seemed to be applicable to large-scale continuous production was that developed by Fischer and co-workers (*25*, *26*). This is a solvent extraction process in which the hafnium is preferentially extracted from an aqueous phase consisting of a concentrated sulfate, thiocyanate solution, with a 1 *M* HSCN ether solution (Stage I). The ether phase is then equilibrated with a new aqueous phase containing equal weights of ammonium sulfate and thiocyanate, whereupon the zirconium is preferentially extracted into the aqueous phase (Stage II). The ether solution enriched in hafnium is then equilibrated with a fresh aqueous phase consisting of an acidified ammonium sulfate solution (Stage III), and under these conditions the metal ion concentration in the ether phase is reduced, and the aqueous phase contains the hafnium concentrate ready for recycling. The details of the extraction process were worked out empirically and probably would be difficult to study theoretically because of the high concentrations used in the solutions.

TABLE 7

Aqueous phase			Benzene phase		
Acid	*Conc.*	M^{+4} *conc.*	*Diketone*	*Conc.*	K_{Zr}/K_{Hf}
$HClO_4$ (*27*)	2 *N*	0.003	Thenoyl trifluoroacetone	0.004–0.07	21
HCl (*10*)	0.2 *N*	0.01–0.02	Trifluoro acetylacetone	0.025–0.075	15

Within the past two years other successful solvent extraction processes have been worked out, using essentially the same system used by Connick and McVey in the study of the aqueous chemistry of zirconium and hafnium. The ratios of the zirconium and hafnium equilibrium constants for the extraction reaction (equation (1)) are given in Table 7.

These data show that in such systems zirconium is preferentially extracted into the benzene phase, and the magnitude of the *K* ratio indicates that a significant separation is possible. In such an extraction system the hafnium content of a zirconium preparation can be reduced from 1 mol per cent hafnium to less than 0.05 mol per cent in several extractions, or increased from 5–7 mol per cent to 99+ mol per cent hafnium in a half-dozen extractions.

Ion-Exchange Processes. Similarly cation- and anion-exchange systems have been successfully applied to the separation of zirconium and hafnium (*28–31*). A summary of the resin and eluant used are given in Table 8.

TABLE 8

Ion-Exchange Separation of Zirconium and Hafnium

	Resin	*Eluant*
20.	Dowex-50	6 *M* HCl
21.	Dowex-50	0.5 *N* HNO_3—0.1 *M* Citric acid
22.	Dowex-1	0.5 *M* HF—1 *M* HCl
23.	Amberlite IRA-400	0.2 *M* HCl—0.01 *M* HF

In general the zirconium and hafnium are exchanged with the resin by a batch operation and the zirconium and hafnium resin is then placed on the top of a column and eluted. All experiments reported to date have been on a micro or milligram scale, and no data are available on the performance of these columns on a larger scale. It is interesting to note that the order of elution for the anion exchanger is the reverse of that for the cation exchanger. High-purity specimens of both zirconium and hafnium apparently can be obtained in this manner.

Other Processes. Just recently an absorption process (*32*) was reported in which a methanol solution of the mixed tetrachlorides is passed over activated silica gel, whereby the hafnium is preferentially retained on the gel, and spectroscopically pure zirconium is obtained from the effluent. If the incoming solution (20 per cent MCl_4 in CH_3OH) has a hafnium-zirconium ratio of 0.02, a product spectroscopically free of hafnium will be obtained up to the point where one pound of ZrO_2 has entered for every five pounds of silicon dioxide (28–200 mesh) in the column. Methanol is used to flush the solution through the column. Flow rates of 20 cm./hr. were satisfactory. The zirconium and hafnium on the column can be stripped by washing with 2.5 *M* anhydrous HCl in methanol or 7 *N* aqueous H_2SO_4. The column can be stripped preferentially to give hafnium concentrates. This process and the fractional distillation of the 3 *M* $Cl_4 \cdot 2POCl_3$ compounds (*21*, *33*) are of importance because they utilize the anhydrous chlorides which are normally produced in the existing commercial operations. They would be of still greater importance if the purified $ZrCl_4$ could be recovered after the hafnium elimination step.

LITERATURE CITED

(1) *Chem. Eng. News*, **28**, 4112 (1950).
(2) ZACHARIASEN, W., MDDC-1151.

(3) *Chem. Eng. News*, **27**, 223 (1949).
(4) HARRIS, S. P., S. RASSMUSSEN, H. SCHROEDER, AND G. THOMAS, ANL-4277.
(5) POMERANCE, H., ORNL 366, 577.
(6) CONNICK, R., AND W. MCVEY, *J. Am. Chem. Soc.*, **71**, 3182–91 (1949).
(7) KING, E. L., AND W. REAS, *ibid.*, **73**, 1804–5 (1951).
(8) CONNICK, R., AND W. REAS, *ibid.*, **73**, 1171–6 (1951).
(9) LEDEN, I., *Z. physik. Chem.*, **188**, 164–6 (1941).
(10) SCHULTZ, B. G., AND E. M. LARSEN, *J. Am. Chem. Soc.*, **72**, 3610–4 (1950).
(11) LARSEN, E. M., AND A. GAMMILL, *ibid.*, **72**, 3615–19 (1950).
(12) BRITTON, H. T. S., *J. Chem. Soc.*, **127**, 2133–40 (1925).
(13) BRITTON, H. T. S., "Hydrogen Ions," D. Van Nostrand Co., Inc., New York, **1929**, p. 256.
(14) MOELLER, T., *J. Am. Chem. Soc.*, **63**, 2625–8 (1941).
(15) MOELLER, T., AND H. KREMERS, *J. Phys. Chem.*, **48**, 395–405 (1944).
(16) DE BOER, J. H., AND A. E. VAN ARKEL, *Z. anorg. allgem. Chem.*, **141**, 284–8 (1924).
(17) COSTER, D., AND G. HEVESY, U. S. Patent 1,660,440 (April 17, 1928).
(18) British Patent 220,936 (August 25, 1923).
(19) LARSEN, E. M., W. C. FERNELIUS, AND L. L. QUILL, "Inorganic Synthesis," McGraw-Hill Book Co., Inc., New York, **1950**, Vol. III, pp. 67–77.
(20) WILLARD, H. H., AND A. FREUND, *Ind. Eng. Chem., Anal. Ed.*, **18**, 195–7 (1946).
(21) VAN ARKEL, A. E., AND J. H. DE BOER, *Z. anorg. allgem. Chem.*, **141**, 289–96 (1924).
(22) DE BOER, J. H., *ibid.*, **165**, 1–30 (1927).
(23) SCHUMB, W. C., AND F. J. PITTMANN, *Anal. Chem.*, **14**, 512–15 (1942).
(24) Private communication, Frank DeRewal, DeRewal International Rare Metals Company, Philadelphia, Pennsylvania.
(25) FISCHER, W., AND W. CHALYBAEUS, *Z. anorg. Chem.*, **255**, 79–100 (1947).
(26) FISCHER, W., W. CHALYBAEUS, AND M. ZUMBUSCH, *ibid.*, **255**, 277–86 (1947).
(27) HUFFMAN, E. H., AND L. J. BEAUFAIT, *J. Am. Chem. Soc.*, **71**, 3179–82 (1949).
(28) SEABORG, G. T., AND K. STREET, *ibid.*, **70**, 4268 (1948).
(29) BENEDICT, J. T., W. C. SCHUMB, AND C. D. CORYELL, Abstracts, 118th Meeting of the American Chemical Society, Chicago, 1950.
(30) KRAUS, K., AND G. E. MOORE, *J. Am. Chem. Soc.*, **71**, 3263 (1949).
(31) HUFFMAN, E. H., AND R. C. LILLY, *ibid.*, **71**, 4147 (1949).
(32) HANSEN, R. S., K. GUNNAR, A. JACOBS, AND C. R. SIMMONS, *ibid.*, **72**, 5043–5 (1950).
(33) KATZ, J. J., AND D. M. GRUEN, *ibid.*, **71**, 3843–4 (1949).

A LABORATORY PRESSURE REGULATOR

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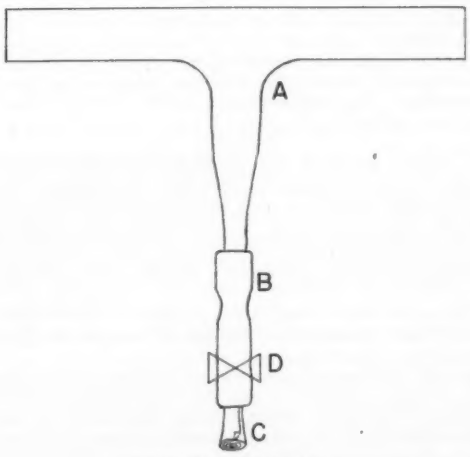
WHEN performing low-pressure distillations in the laboratory, one of the major problems is that of keeping the pressure constant. A number of devices have been described for this purpose.

A controllable constant-leak device can be made in a few minutes from materials available in every laboratory. This consists of a piece of small-diameter gum rubber tubing, *B*, attached to a glass T-joint, *A*, with a fairly tight roll of tissue paper, *C*, forced into the tubing. In operation, the T-joint with tubing attached is installed in the vacuum system, and the amount of leak is controlled by means of a small screw compressor, *D*. As long as the source of vacuum remains fairly steady, the pressure in the system remains constant within surprisingly small limits.

A unit of this type used in conjunction with a Nelson mechanical pump and a one-liter surge chamber was found to be capable of controlling the pressure within less than 1 mm. at pressures as low as 5 mm. With a static system (closed, no distillation) this apparatus held a pressure of 12.0 mm. so steadily for one and one-half hours that no fluctuation could be observed with an ordinary U-tube manometer. During several distillations at pressures ranging from 10 to 50 mm. the apparatus was found to hold the pressure constant throughout the operation. This device worked with a water aspirator also, but large fluctuations in water pressure had a marked effect on the system.



Constant-leak Device

GOETHE AND CHEMISTRY[1]

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GOETHE showed active interest in many fields of natural science. It is quite well known that he was a botanist, an anatomist, and a physicist, and in his writings we find also a concern for mineralogy and geology. It is therefore not surprising that his interests also extended along chemical lines. Let us trace this thread of chemical interest which is woven into Goethe's life history. Although chemistry was hardly his chief scientific forte, it was a subject which at times truly captivated his diversified mind and enlisted his active participation.

In his early youth Johann Wolfgang Goethe received much of his education from his father. The lad was schooled in the ancient and modern languages and had access to the enclyclopedic works of Bayle, Morhof, and Gesner[2] in the large library at his home.

It may be assumed that young Goethe was, after a fashion, fitted with chemical fundamentals before he left home for Leipzig in September, 1765 (*2*).

After almost three years, Goethe returned home a sick young man. It was at this point that be became interested in alchemy through the influence of his attending physician, a Dr. J. F. Metz who was a supporter of Paracelsus. The good doctor was an abstruse man. In "Dichtung und Wahrheit" (Book 8), Goethe recorded (*3*):[3]

> With certain powders, which may have been some kind of digestive, he was not so reserved, but that powerful salt, which could only be applied in the greatest danger, was only mentioned among believers; although no one had yet seen it or traced its effects. To excite and strengthen our faith in the possibility of such a universal remedy, the physician, wherever he found any susceptibility, had recommended certain chemico-alchemical books to his patients. . . .

To know more of the "non-failing salts" (possibly Glauber salts) Goethe read with his mother and a friend of the family, Fräulein Suzanna von Klettenberg, a book by Welling, entitled "Opus Mago-cabbilisticum et Theosophicum," in which, among other things, the salts were described. Goethe also refers in "Dichtung und Wahrheit" to books by Paracelsus, Basilius Valentinus, van Helmont, and Starkey, as well as one entitled "Aurea Catena Homeri."[4]

Imagine the enthusiasm which Goethe exhibited as he set up a small laboratory in his attic room. Here, amidst alembics and retorts, we see him standing before his wind furnace, or poring over the chemical compendium of Boerhaave. This picture of Goethe reminds one of the alchemist of old who believed that a secret ingredient or some magic factor was all that was needed to perform the transmutation of mercury to gold, and whose twentieth century descendant at Oak Ridge has just recently accomplished the transformation of gold to mercury (*5*). Experiments and studies brought Goethe closer to methodical chemistry, that is, they led him from the older ideas of alchemy toward the concept of experimental scientific chemistry (*6*).

In March, 1770, Goethe left Frankfort for further study of law at the University of Strassburg. His interest in chemistry had not waned, for here he attended lectures on chemistry given by Professor Jakob Spielmann. His attention to "Chymie" is also exhibited in a letter to his friend, Fräulein von Klettenberg. In this letter, dated 26 August, 1770, Goethe writes, "Und die Chymie ist noch immer meine heimliche Geliebte."

During his stay in Strassburg, Goethe had opportunities of taking several trips into Alsace and Lorraine. On these journeys he visited some chemical concerns including alum factories, glass works, coal mines, and iron works. Here Goethe actually got a glimpse into the practical applications of chemistry as contrasted with the "chemistry" of "Aurea Catena Homeri."

In the summer of 1771 Goethe returned home with his law degree to settle down and begin practice as an attorney. During the next five years chemistry played no recorded part in Goethe's life, but in 1776, having become an official at Weimar, we find him visiting the glass makers of his territory in Schleusingen, Stützerbach, and Ilmenau. He also visited charcoal burners, and went into coal mines and iron works, noting in his daybook: "Viel von Bergwerkssachen geschwatzt" (August 1, 1776), also (in Ilmenau): "Silberprobe bei Heckern selbst gemacht" (August 4) and on August 10: "Meist zu Hause Chymie gelesen" (*7*).

In 1777 Goethe made his first journey to the Harz mountain district which further directed his attention to mining, and soon he was given direction of the war and road-building commission. His work in mining

[1] This article was a term paper written for the German Proseminar class, conducted at Bradley University by Professor Robert Rie.

[2] Bayle's "Dictionaire Historique et Critique" was an encyclopedia devoted almost exclusively to biography. Morhof's "Polyhistor Literarius, Philosophicus, Practicus," a popular handbook which first appeared in 1688, contained a vast amount of bibliographical material, a history of most of the sciences, a methodology, rhetoric, poetics, and a systematic, though short, treatment of physics, astronomy, chemistry, botany, and zoology. Gesner's "Primae Lineae Isogoges in Eruditionem Universalem" (Göttingen, 1756) gave an introduction to philology (embracing also a treatment of the arts), history, and philosophy (*1*).

[3] Translated by J. OXENFORD, "Autobiography of Goethe," S. E. Cassino & Co., Boston, 1884, Vol. 1, p. 283.

[4] A book in which the cycle of nature is described in a beautiful, half-mystic, half-scientific way (*4*).

and road-building directed his thinking to geology and mineralogy, while that in forestry and agriculture led to a considerable interest in botany (*8*). We find in a letter to Frau von Stein (August 16, 1786) his appreciation of the need for chemistry in mineralogy: "In der Mineralogie kann ich ohne Chymie, nicht einen Schritt weiter, das weiss ich lange. . . ." (*7*).

In 1789 and several years following, Goethe concentrated his scientific efforts toward his "Farbenlehre." In the third division of the work Goethe treats the "Chemischen Farben." As chemical colors he designates those "welche wir an gewissen Körpern erregen, mehr oder weniger fixieren, an ihnen steigern, von ihnen wieder wegnehmen und andern Körpern mitteilen können, denen wir denn auch deshalb eine gewisse immanente Eigenschaft zuschreiben" (*8*).[5] It is interesting to note that Goethe was quite familiar with the literature of his time which pertained to this subject. In the section "Von der chemischen Aktion des Lichts und der farbigen Beleuchtung," we find him telling of some work done by Scheele, the noted Swedish chemist (1742–86).

In Weimar, Goethe had, through the years, three chemical advisors: Bucholz, Göttling, and Döbereiner.

Wilhelm Bucholz (1734–98), chemist, botanist, and Weimar's court apothecary, served also as a member of the council of mines and as doctor of the court. On matters botanical and chemical, he was Goethe's advisor for 20 years, and earned the latter's friendship and respect.

It is fitting that the reader should be reminded of the state of chemical knowledge existing at this time. Around the middle and the second half of the eighteenth century many important chemical discoveries and phenomena were being uncovered. The death blow came to the phlogiston theory about 1785 and the development of systematic chemistry was starting. Changes were being made in the universities of Europe to cope with this advance in chemistry.

Recognizing this, Carl August, Duke of Saxony-Weimar, with the collaboration of his Privy Councillor, Goethe, established a professorship in chemistry at the Gesamt Akademie of Jena in 1789. The first man to hold this chair was Johann F. Göttling (1753–1809). A student of Bucholz, he was a fine experimenter and had become acquainted with Carl August and Goethe through their many visits to the court apothecary shop. In 1785 the duke had sent Göttling to Göttingen for two years of study, followed by a student trip to England and Holland, from which Göttling returned to find the professorship in chemistry awaiting him at Jena.

Goethe greatly aided the new teacher in getting started and, over the years, consulted with him on many chemical matters of official and private nature, taking active part in some of his chemical experiments, and conferred with him on the studies on "Farbenlehre" (*9*).

When, upon the death of Göttling, the position at Jena was again open, Carl August wanted a successor who was also a man of practical chemistry. Gehlen, professor of chemistry at Munich, was asked for suggestions and proposed Johann W. Döbereiner.

Döbereiner (1780–1849) was also an apothecary in the beginning of his career but later acquired considerable practical knowledge in other chemical lines. Döbereiner met with Goethe, who was now Privy Councillor and Minister of State, on November 8, 1810, and the two spent two days discussing plans for equipping the chemical laboratory at the university. A laboratory was first established in the former Jena palace, using old chemical apparatus on hand at Weimar, material from Göttling's incumbency, and books obtained from the ducal library (*10*).

The experimental work soon outgrew the space provided in the palace and in 1816, a house was acquired and fitted for Döbereiner's needs (Hellfeld Haus). In 1833 a new technical-chemical laboratory (plans previously drawn by Goethe) was built in the garden.

Under Goethe's management the chemical Lehrkanzel of the University of Jena developed into the "Chemischen Anstalt."

Döbereiner's experiments and studies at Jena were varied and numerous. He introduced practical chemical instruction into the laboratory. Some of the topics which were discussed in correspondence between Goethe and Döbereiner included (*11*):

Phosphorescence of brilliants
Minerals for the chemical preparations collection
Potassium in felspar, gypsum in corals
Sulfur water of Berka
Coal tar
Iron content of a sandstone
Experiments with plant juices
Siliceous earth in Carara marble
"Feuergas" from coal and water

Probably Döbereiner's most brilliant work was with platinum in which "he noticed a glowing of platinum in a mixture of hydrogen and oxygen gas" (*11*). From this finding he fashioned a new chemical lighter—the Döbereiner Feuerzeug. Also noteworthy was his discovery of the "Döbereiner Triads," forerunner to the periodic table and preceding the work by Pettenkofer, Meyer, and Mendeleev.

Goethe was also acquainted with other chemists of the times, some personally, some through correspondence, and others through their writings. Included in this group are such personages as Josef Gruner, Anton Lavoisier, Heinrich Wackenroder, Carl Scheele, Berzelius (*12*), Mitscherlich, Rose, Bergman,[6] and others.

Goethe's interest in alchemy and chemistry is reflected in many of his works, for example, in "Faust" and in "Dichtung und Wahrheit."

[5] Translation: . . . "which we can excite in certain substances, more or less fix, intensify in them, take away from them again and impart to other substances, to which we then therefore also ascribe a certain immanent property."

[6] It is said that Bergman's theory of double and simple chemical affinities gave Goethe stimulus for his "Wahlverwandschaften."

And so we see that an interest in chemical phenomena ran quite consistently throughout Goethe's life. Although chemistry seemed to play a minor role among his scientific endeavors, it was nevertheless, a subject which he held in high regard.

LITERATURE CITED

(1) BIELSCHOWSKY, A., "Life of Goethe," G. P. Putnam, New York, 1905, Vol. 1, p. 421.
(2) ZEKERT, O., *Pharmazeutische Monatshefte*, **14**, 131 (1933).
(3) ZEKERT, O., *ibid.*, p. 132.
(4) BIELSCHOWSKY, A., *op. cit.*, p. 93.
(5) *The Laboratory*, **17**, No. 4, 130.
(6) WALDEN, P., *Z. angew. Chem.*, **43**, 794 (1930).
(7) WALDEN, P., *ibid.*, p. 796.
(8) ZEKERT, O., *op. cit.*, p. 133.
(9) ZEKERT, O., *ibid.*, p. 134.
(10) PRANDTL, W., J. CHEM. EDUC., **27**, 177 (1950).
(11) ZEKERT, O., *op. cit.*, p. 135.
(12) BAUDISCH, D., J. CHEM. EDUC., **27**, 68 (1950).

ARNE TISELIUS

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THE Nobel Prize in chemistry for 1948 was awarded to Arne Tiselius of the University of Upsala for his work on electrophoresis and adsorption analysis and for his discovery of the complex nature of the serum proteins.

He was born at Stockholm on August 10, 1902. His father was a mathematician. The boy's active mind was early directed toward chemistry and biology by an inspiring teacher, who entrusted him with a key to the high-school laboratory, so that he could carry out chemical studies after school hours. Attracted to Upsala by the fame of Svedberg's brilliant successes, Tiselius matriculated there in 1921 and took his first degree in 1924. He then became research assistant under Svedberg, with whom he worked on a method of determining the mobility of proteins. This involved a study of their electrophoretic migration and Tiselius directed his attention especially to the elimination of the possible source of errors in the moving boundary method. He also showed how the procedure could be applied in studies of the purity of proteins. These investigations formed the basis of his doctoral thesis (1930).

He stayed on at Upsala as assistant professor of chemistry. To broaden his research horizon he took up the study of adsorption and diffusion on and in solids. Needing well-crystallized zeolites as test materials, he made a long trip to the Faroe Islands in 1932, where he personally collected beautiful and usable specimens. He discovered the factors which govern the diffusion of water into zeolite crystals and developed an excellent method for measuring the diffusion of water vapor and other gases into such solids. He also made studies of the kinetics of these processes in the presence of various gases.

In 1934–35, he was at Princeton as a Rockefeller Fellow. On his return to Upsala, where he hoped to be given a professorship, his qualifications, both theoretical and experimental, were fully recognized, but the only vacant chair was awarded to another who was equally meritorious. Tiselius now decided to concentrate on biochemistry, which appealed to him as offering the most interesting problems, whose solutions would probably come from the application of physical methods. He therefore resumed his electrophoretical studies. He redesigned the apparatus for electrophoretical analyses so that the movement of the boundaries could be followed optically and so that samples could be taken from different parts of the tube. The tube was made with long and narrow rectangular sections in contrast to the circular form previously used. The new design permits the use of much higher potential gradients, with consequent increase in resolving powers. This apparatus, improved from time to time, has now been put into use in laboratories wherever biocolloids are receiving serious study. It serves as a means of purification, analysis, and isolation.

Tiselius has also done important work in adsorption analysis, and he has succeeded in making quantitative separations of closely related substances such as amino acids, carbohydrates, and fatty acids. He has shown how molecular weight-frequency curves can be obtained from the adsorption analysis diagrams of high polymers. His "salting out adsorption" method is now being developed and promising results have been obtained with respect to the fractionation of mixtures of proteins and high molecular peptides.

Through Svedberg's efforts, a generous patron endowed a permanent chair in biochemistry at Upsala, and Tiselius has occupied this professorship with distinction since its establishment in 1937.

THE ART OF SEARCHING THE LITERATURE

II. The Literature Survey Proper

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DESPITE its being an art, efficient literature searching should follow certain forms if it is to be carried out in an effective manner. Some methods found useful to investigators are briefly described in what follows.

The literature survey proper is made to give background to a problem, orient an investigator in a subject, or trace a historical development. Such a survey may be in the form of (1) a review; this is a connected exposition listing references to articles from which material is cited in the text of the review, implying selection on the searcher's part, or (2) a title bibliography; this usually is as complete a bibliography on the subject as possible (applying the law of diminishing returns), or (3) an author bibliography; this is a tracking down of one investigator's work, or (4) an annotated bibliography of abstracts; this may be either from abstract journals or from original articles, but also implies critical selection and evaluation of the literature.

The final form of such bibliographies represents an investigation which is often as publishable as an original scientific study. Abstract bibliographies may be typed one abstract to a page, permitting arrangement by subject and the taking of further notes on the page when the original reference is consulted; chronological order by the original reference should be the arrangement within the subject. The secondary or abstract journal should always be given and preferably on a separate line from the original reference. It is also preferable, for uniformity's sake, to use standard library methods of listing, such as giving complete pagination. This is necessary to indicate the character of the article, *i.e.*, whether an extensive study or just a note, and is also useful in ordering photostats. Abstracts are usually typed in block form without paragraphing. The following is an example.

A New Viewpoint in the Study of Cellulosic Textile Fibers
Farr, Wanda K.
Textile Research 7, 65–9, 1936
(C. A. 31, 2440, 1937)

The cellulose membrane can be separated into ellipsoid cellulose particles, crystalline in character, and a cementing material which is colloidal in behavior. The cementing material can be extracted with weak acids or alkalies. Pectic acid has so far been identified as one of its ingredients. Reactions of the separated membrane constituents with cuprammonium hydroxide show that viscosity variations are caused by the cementing material only and not by the cellulose component.

A subject bibliography should be prefaced by a table of contents indicating the breakdown of subjects, and should be accompanied by a carbon copy arranged by author so that one author's work can also be traced. All bibliographies should be accompanied by a statement of the years, sources, and key index words searched.

Effective searching involves more than thorough methodical coverage, and skill in using indexes requires more than a subject knowledge. Material often is not indexed in the way requested. A certain amount of imagination in thinking up key words and related topics is necessary. For instance, a search was recently made on the subject "Rates of diffusion of swelling agents and reactants through cellulose fibers." Upon consulting the indexes of *Chemical Abstracts* no entries were found under Cellulose or under Fibers using the words "rates" or "penetration." To make an adequate survey of this subject it was necessary to search the following key words under the main index headings both of Cellulose and of Fibers: (1) absorption, (2) dyes and indicators; penetration of, (3) structure, (4) grinding effect, (5) reactivity, (6) water sorption, (7) swelling, (8) degradation, (9) hydrolysis, as well as the commonly known reagents for cellulose, *viz.*, NaOH (mercerization), cuprammonium, nitric acid, acetic acid (acetylation), carbon bisulfide (xanthation), and to inspect all such abstracts, selecting only work with a *kinetic* approach, discarding that which was only qualitatively descriptive. Thus, ability to analyze the subject into constituent aspects furnished the clues.

A broad view of the subject, and of the purpose of a search, bringing in correlated background information, often leads to interesting by-products which may pay dividends ultimately in eliminating necessity of another search at a later date. Thus, a search on conversion of propyl alcohol into propionic acid by bacterial fermentation included catalytic oxidation of propionic aldehyde; although this was only correlative and not directly pertinent, the first search led to a request later for this information which had been already collected due to foresight on the part of the searcher at the time the first subject search was made.

An intimate knowledge of how entries are listed in the indexes is necessary. Often the different methods of organic nomenclature present problems in searching. For instance, one chemist found nothing in *Chemical Abstracts* on meta- and para-ethyl cyclohexanols whereas a technical librarian, after an orientation in Richter's book, "Organic Chemistry," which showed that these compounds were known as 3-ethyl and 4-ethyl cyclo-

hexanols respectively, searched under cyclohexanol, ethyl 3- and 4-, and found some information.

While knowing the investigator who has been intimately connected with a subject permits tracing through the published work of such an author, and thus may yield a bibliography of the subject already prepared by him, requiring only to be brought up to date, there are pitfalls in name searching as well, due chiefly to difference in transliteration of foreign names; thus Zalkind in *Chemical Abstracts* becomes Salkind in *Chemisches Zentralblait*. Recently, for a bibliography of the work of Dr. Frey-Wyssling, indexes revealed no items prior to 1935, whereas entries of somewhat related lines of investigation were entered under A. Frey. Apparently Dr. Frey had subsequently added his mother's surname of Wyssling to prevent some confusion with another author of the same name working in a related field of investigation.

How far back to search involves a knowledge of the history of the subject. Thus, for a simple bibliography on kinds of materials used for hydraulic brake fluids it would hardly be worth while to focus on the years prior to 1917 when extensive automotive developments first brought up interest in this subject; likewise, the topic "emulsion polymerization" is hardly likely to be listed in the first decennial index of *Chemical Abstracts* covering the dates 1907–16, since polymerization techniques were not well developed until a later year.

Most of all it is necessary to know the index journals best suited to the subject of the search. For instance, a search on the point whether nylon was first a trade name for a product and subsequently became a generic term is best done through newspaper announcements or in Industrial Arts Indexes from 1938 on, the year when nylon was commercially introduced, since Industrial Arts Index more or less completely covers the field of trade magazines, a great many of which are overlooked by the more scientific index journals.

In a survey of any extent, therefore, a tentative method of its organization should be mapped out, an analysis of the subject into its various aspects made, and key words thought out as clues to index searching.

The general steps to take in making a subject search would be: First, look up any unfamiliar terms in dictionaries, handbooks, or encyclopedias. (This will give one a general orientation, some clue whether the subject is primarily in the field of physics, chemistry, biology, etc., and an idea of the history of the subject, all this defining sources and how far back to look.) Next, choose from the subject book catalogue in a library a good modern text in that field or a comprehensive treatise, like Mellor, for inorganic; Richter, Whitmore, Bernthsen, or Karrer for organic, and read the pages indicated in the book's index or tables of contents on the subject. This will turn up key words to search in abstract journal indexes. If the book is well documented, such as Ellis' "The Chemistry of Petroleum Derivatives," extensive bibliographic references to the original or abstract literature will be given at the bottom of each page, or at the end of the chapter, which may make it unnecessary to search the abstract journals prior to that date, unless a complete bibliography is desired, since the author of the book has already made the selective search. Sometimes *all* well-known texts on the subject are consulted to get differences in viewpoint, and it will be found that some authors dismiss a subject with a paragraph, while others expand it into several pages, depending on the specialty of the author himself. It is well to include quotations from the best and most modern text or monograph in the bibliography. Book references are not arranged in the final bibliography by subject but precede the subject matter in a section of their own. Their format should be as follows:

OTT, E.: Cellulose and Cellulose Derivatives
Volume V of High Polymers
Interscience Publishers, Inc., N.Y.C., 1st edition, 1943
pp. 2, 5–6, 8–12, 19, 203–205, 312
P. 72–75 Kinetic proof of structure of cellulose
Refers to K. Freudenberg and C. Blomquist
Ber. 68B 1935, 207c

This illustration shows how book references are cited by author.

Following this step, an annual review should be consulted if the subject is broad enough. Such reviews are the *Annual Reports on the Progress of Chemistry* of the Chemical Society (London) and the *Applied Chemistry Reports* of the Society of Chemical Industry, or in annual review articles of journals, such as *Chemical Week*. Any of these may give the present state of the subject and the year's best references to original work. However, this step in bibliography is often omitted and approach is made directly to abstract journals.

In using abstract journals, known as secondary reference sources, it is best to start with the later volumes and work backwards in the hope that review references with prepared bibliographies on earlier work will also be encountered here. Use, of course, should be made of cumulative and decennial indexes where they exist, and it is here that the searcher's art best comes into play.

A great deal of material is buried because of poor indexing due to poor abstracting; however, well-correlated topic key words can dig it out ultimately. This criticism, however, cannot be levelled at *Chemical Abstracts* indexes, which, it is acceded, approach perfection. The fourth decennial index, of which the author volumes have been issued complete, and the subject volumes are also complete as of this date, represents five miles of index card files![1] Formula indexes of *Chemical Abstracts* are most useful at the beginning of a search to work out nomenclature and to find proper entry in the index.

Another standard secondary source in English is *British Abstracts*, which is divided into Pure Science and Applied Science editions. Its abstracts are longer and more detailed than those of *Chemical Abstracts* (*i. e.*, where a *Chemical Abstracts* abstract will say "27 solvents were tried," *British Abstracts* will list the actual solvents) but the *British Abstracts* indexes have entries by key words of the title, rather than by subjects. It is per-

[1] CRANE, E. J., *Chem. Eng. News*, 25, 1188–9 (1947).

haps more complete than *Chemical Abstracts* on foreign patent coverage and on technologies such as in the textile industry. The one disadvantage is the absence of decennial indexes.

The third standard secondary source is *Chemisches Zentralblatt* in German. It has the longest abstracts of all abstract journals and goes further back in the literature than either of the others mentioned, *i. e.*, 1830 under various titles, as against 1907 of *Chemical Abstracts*. Hence it is useful in searching the early literature. It also has the advantage of semiannual author indexes.

Some abstract journals in various fields are listed below, and the best for search purposes are starred. The others are either too new to cover a range of years or have very difficult arrangements of indexes, or very selective analytical abstracts, and are really current literature services.

Chemical and General

Chemisches Zentralblatt, 1830*
Chemical Abstracts, 1907*
British Abstracts
Industrial Arts Index (no abstracts), 1913*

Engineering and Physics

Engineering Index (no abstracts), 1884*
Electronics Engineering Master Index, 1925–1945
Inst. Metals (London) Abstracts (for metallurgy and mining, 1921*)
Am. Soc. Metals Review (for alloys), 1947
Science Abstracts, A and B

Biology

Biological Abstracts
Bibliography of Agriculture

Miscellaneous

West, C. J., Bibliography of Paper Making, 1936–1945, and Annual Suppl.*
Bulletin of the Institute of Paper Chemistry
J. Soc. Dyers Colourists (abstract section)
Harris, Natural & Synthetic Fibers (an abstract service)
Textile Digest of Textile Research Institute
Bulletin Institut Textile de France (abstracts section)
Mark and Proskauer, Resins, Rubber and Plastics (2nd series)

In going through an extensive number of indexes by years it is well to be neat and methodical; records of pages found in index entries must be kept accurately for a reference wrongly recorded might as well never have been found. *Chemical Abstracts* indexes make few mistakes in page entries, but they do occur, and if an item is not found on page 689, for instance, one should try page 869 or 968 or 68.

A separate notebook should be kept as a permanent record for all searches, with the date when search was begun, the problem or subject of the search, key words searched, the year of sources consulted noted, with pages for each source giving page notations from the index. In certain cases the subjects should be noted opposite the page entries (especially opposite those discarded), for possible future use. Separate notebook pages should be used for cross references or earlier references referred to in articles to be tracked down subsequently.

Finally, and as a last step in the search, the original literature should be consulted, whenever possible or easily available, or a selection should be made from the abstracts of those papers worth reading in the original, because errors do creep into abstracts.

Types of original literature often neglected by chemists as search sources are government publications, house organs, and graduate theses. The separate publications of the National Bureau of Standards and the American Society for Testing Materials are often valuable. The Inquiry Reference Service of the U. S. Department of Commerce often gets out pamphlets such as "Basic Information Sources of Plastic Materials" giving a general orientation on a subject. Commercial companies and management consultants get out useful compilations such as the George S. Armstrong & Company, Volume VII on "The Plastics Industry" and Volume VIII on "The Synthetic Fiber Industry" which give a fine over-all and statistical picture of an industry. Unfortunately these are not completely covered in abstract journals. Graduate theses are of course obtainable. For all such material the abstract subject file of a special technical library must be relied on, since those of interest are indexed by a good technical librarian who follows the new publications in the special field and acquires them as soon as announcement of them is encountered in current magazines.

From this original literature usually an evaluative abstract of his own has to be made by the bibliographer. Such abstracts are seldom contents-of-the-article type, but detailed points are emphasized, such as methods of preparation, constants, results. Implications of the article are noted as they occur to the searcher. For instance, in an article on radioactive carbon-tagged acetic acid lay a dormant implication of the possibility of the use of such a radioactive material in the study of rates and degrees of acetylation of cellulose. The Mellon Institute Library and chemists have developed some very complete blank forms for taking notes on original literature, with spaces giving room for noting type of article, where located, purpose and scope, critical opinion, etc.

Among the most difficult of searches are those in the field of organic chemistry. Properties, or identification of a compound already prepared in the laboratory, or methods of preparation may be sought. For identification, the empirical formula having been determined, the formula indexes of Richter's "Lexicon," up to 1910 referring to Beilstein, or Stelzner's "Literatur-Register" which includes data from 1910 to 1921 can be consulted, and the formula index of *Chemical Abstracts* from there onward. If methods of preparation are sought, there is the series of 30 volumes of "Organic Syntheses" up to date and the two collective volumes of these edited by Blatt. Also, the six volumes of "Organic Reactions" under the editorship of Roger Adams.

The best source up to 1939 is the fourth edition of Beilstein. This edition has adopted the Prager-Jacobsen classification system based on structure of a compound related to its parent class. There is no space

here to go extensively into the complications of searching in Beilstein. A brief two-page description of the classification system appears in *Chemical & Metallurgical Engineering* (Vol. 22, p. 256–8), while Huntress' "A Brief Introduction to Usage of Beilstein" is a competent, extensive text. Suffice it to say that four aids to anyone using Beilstein are: a detailed table of contents; an index to each volume and a general index to 27 volumes; a code system locating each substance by means of a key compound and number; a general formula index and a definite arrangement by the principle of latest position of the parent compound, if derived from two or more functional groups, when the compound sought is converted back to its "stem nuclei" by substituting hydrogen for all elements without breaking ring structures of the compound. Within the three main classes of acyclic, Volumes 1–4; isocyclic, Volumes 5–16; heterocycle compounds, Volumes 17–27, arrangement is by decreasing saturation and increasing complexity. Volumes 30–31, naturally occurring compounds, have their own peculiar arrangement and subject index. Mellon's "Library Guide to the Chemist," pages 127–153, gives some practical examples of exceptional compounds presenting difficulties when the simple rules given above are followed.

Organic chemistry literature is one of the oldest and most systematized; it is curious to note that the most complex compounds seem to have been the first to be worked on and are reported in the oldest literature.

PATENT SEARCHES

The rules of practice in the United States Patent Office require that in every original application the applicant must distinctly state under oath that to the best of his knowledge and belief the invention has not been in public use or on sale in the United States for more than one year prior to his application, or has not been patented or described in any printed publication in any other country before his invention for more than one year prior to his application (in the case of applications for patent filed prior to August 5, 1940, this period is two years instead of one year), or has not been patented in any foreign country, nor has an application been filed by himself or his legal representatives or assigns in a foreign land more than 12 months prior to his application in this country.

Publication and application dates, therefore, weigh heavily in the balance in obtaining a patent grant. Good literature, patent, and company record searches are obviously of great importance to the inventor and the patent attorney.

There are two types of patent searches depending on the objectives:

(1) Anticipation searches, done on the "state of the art" before filing an application, to determine advisability of filing (*i. e.*, if invention really exists) and how broadly claims can be drawn to make a strong patent. Here bibliographies enable the attorney to distinguish more clearly the novelty of the invention. In anticipation searches the searcher must always take the view that something prior *may* exist though a report "no pertinent material found" is satisfactory to the attorney. The ruling is that disclosures in print in any country more than a year before the patent application is made, even if the inventor did not know of such disclosure, is anticipation and counts against him.

(2) A domination search for patents already granted in the field is made before buying or selling a device or obtaining a license under a patent. This consists of a reading of pertinent patent claims 17 years prior to the invention in question.

A very exhaustive search for all, and any, anticipatory references in any literature or printed matter whatever is made when sued for infringement. Such a "validity" search takes the highest skill of the searcher's art and may even involve search on public use, covering "ads" and Sears Roebuck catalogues!

Patent searches can be made from abstracts in *The Official Gazette*, without certainty, however, of being complete. There is an annual index to this publication by author and assignee, and a subject index, but no cumulative class index. Librarians are agitating to induce the Patent Office to issue such a useful search tool. In looking up patents in the *Gazette* by company assignee one must remember that failure to find such an assignee may mean that assignment was made after granting of the patent, and it would be necessary to know the inventor's name to find the patent itself. The annual and weekly list of inventions of the *Gazette* is not a true subject index since listing is alphabetical by first word of title with no subject cross referencing, and patent titles often appear not at all indicative of their true subject content. Fortunately, however, obscure titles, like "Composition of Matter" have been recently forbidden by the Patent Office. Therefore, complete subject searching of patents can only be done through weekly class number indexes—a tedious process and thus never certain.

In making a subject patent search the "Manual of Classification of Patents" is consulted, with its latest annual revisions. This has an alphabetical index of class and subclass, as well as an outline of class schedules. The likely classes and subclasses once decided upon, the searcher has the alternative of either looking up the patents in the class as listed in each weekly issue of the *Gazette*, or of going to Washington where there are available all specifications in that category plus file wrappers on any individual pertinent patent which will give a complete history of that patent's prosecution. It is generally conceded that a complete patent search is best carried out on the fully described invention in the specification in the Patent Office Library in Washington by a professional patent searcher, but a list of all patents in a certain subclass will be sent on request and in payment of a fee to the Patent Office.

Aside from the official Patent Office publications of the United States and other countries, there are useful compilations that somewhat ease the searcher's task. The single patent abstract by number can be located through *Chemcial Abstracts* using the Special Libraries

Index to patents 1907–36, the years before a patent index was included in that journal, and the Numerical Patent Index for 1937–46 (Volumes 31–40), published by the A. C. S. in 1949. Foreign patent equivalents to the United States patent can be found in *Chemisches Zentralblatt*. Determination of the date on which a patent number was granted and published in the *Gazette* is aided by Randall and Watson's "Finding List of U.S. Patents," issued by the University of California Press, 1938.

Patent compilations exist for certain subjects, complete up to certain dates. Such are Worden's "Chemical Patent Index," 1915–26; Friedlander's compilation on dye patents, 1877–1925; Winther's "Patente der Organischen Chemie," 1877–1908; and Faust's "Cellulose Verbindungen," 1935. Certain texts like Worden's "Technology of Cellulose Esters" pay special attention to the patent literature.

Patent searches can be submitted as a list of patent numbers or as abstracts arranged chronologically, with the latest on top. A list of patents of borderline pertinency is usually appended. The following is the format for a patent abstract.

U.S. #2,453,275
Preparation of Mixed Saturated-Unsaturated Esters of Cellulose
Seymour, G. W., White, B. B. & Barabash, E. (Celanese Corp. of Am.)
Official Gazette, U. S. Pat. Off., **616**, #2, Nov. 9, 1948, p. 444

Process for the production of mixed organic acid esters of cellulose containing radicals of both saturated and unsaturated aliphatic acids having at least four carbon atoms in the acid radical, which comprises esterifying cellulose with an esterification medium comprising an inorganic acid esterification catalyst, about two mols. of the anhydride of an unsaturated aliphatic acid, each having at least four carbon atoms in the acid radicals, allowing the esterification to proceed, adding an additional amount of the saturated aliphatic acid anhydride, and allowing the esterification to proceed to completion. As a new article of manufacture, cellulose butyrate-crotonate containing from 0.2 to 0.3 crotonyl groups per glucose residue.

Some types of searches are impossible to make in the indexes. Here a technical library's own patent and abstract card files are the best starting point for a search, since they are oriented from one viewpoint and represent careful collection and abstraction of the literature with the investigators' current problems in mind.

Search requests to a library should be as specific as possible and should give a hint of the purpose of the search or to what use it is to be put.

Searches and bibliographies are the productive work of a technical library and are usually given special attention, and a technical librarian fully informed of the object of the search and familiar with the scope and the completeness of the collection in her own library is apt to be the most thorough and efficient searcher.

LITERATURE

CRANE, E. J., AND A. M. PATTERSON, "A Guide to the Literature of Chemistry," John Wiley & Sons, Inc., New York, **1927**.

MELLON, M. G., "Chemical Publications," 2nd ed., McGraw-Hill Book Co., Inc., New York, **1940**.

SOULE, B. A., "Library Guide for the Chemist," McGraw-Hill Book Co., Inc., New York, **1938**.

PARKE, H. G., "Guide to the Literature of Mathematics and Physics," McGraw-Hill Book Co., Inc., New York, **1947**.

MUDGE, I. G., "Guide to Reference Books," Am. Library Assoc., 6th ed., **1936** and suppl.

CONNOLLY, A. G., "Symposium on technical library techniques: Library vs. laboratory research," J. CHEM. EDUC., **20**, 531–3 (1943).

EGLOFF, G., M. ALEXANDER, AND P. VAN ARSDELL, "Problems of the scientific literature survey," J. CHEM. EDUC., **20**, 393–8, 587–92 (1943).

COLE, B. J., "The library vs. the laboratory as a basis for research," J. CHEM. EDUC., **21**, 319–21 (1944).

HOFFMAN, T., "Techniques employed in making literature searches for a patent department," J. CHEM. EDUC., **24**, 546–50 (1947).

LEWTON, L. O., "Libraries, advance scouts for research," *Chem. & Met. Eng.*, **53**, 112–13, 116 (1946).

LEWTON, L. O., "An industrial research library—Celanese Central Library," *Sci. Monthly*, **65**, 390–4 (1947).

BAY, J. C., "Some vital books in science 1848–1947," *Science*, **107**, 485–91 (1948); *Chem. Eng. News*, **16**, 213–14 (1938).

LEWTON, L. O., "The roving librarian," *Special Libraries*, **36**, 75–9 (1945).

JONES, E. L., "Searching the literature of science," *J. Sci. Instruments*, **17**, 253–7 (1940).

WHITFORD, R. H., AND J. B. O'FARRELL, "Use of a technical library," *Mech. Eng.*, **70**, 987–93 (1948).

An ingenious method of pulverizing hard to grind things, such as plastics, pharmaceuticals, insecticides and foodstuffs has recently been announced. Liquid nitrogen in spray form rapidly cools the material to just the right degree of fragility just before it enters the pulverizing mill.

TEACHING FOREIGN LANGUAGES TO RESEARCH STUDENTS[1]

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IT HAS always been agreed that science is universal and international, and that scientists in various countries must be able to communicate with each other. The barriers of language must not be allowed to bar the progress of science, and the men of science have always accepted the necessity of learning to read, if not speak, the languages of eminent colleagues in other lands. This age-old necessity is now sharpened by international tensions and rivalries; the pursuit of knowledge has become a race against time.

Now, less than ever before, can American research afford to overlook any opportunities, and yet our graduate schools are increasingly turning out one-eyed researchers. By this I mean researchers who can read only one language—English. They are blind to research in any other language. Their graduate school transcript solemnly assures us that they can read German and French or perhaps Russian, but the men themselves usually admit that they don't and can't.

This absurd and dangerous situation is not new. Ten years ago an eminent scholar wrote: "One has only to mention the topic in university circles anywhere to be inundated by a flood of hilarious anecdotes, bewildered queries, righteous indignation, and unquotable abuse."[2] Since this was written, the situation has become increasingly acute. Causative factors might be summarized as follows:

Increase in graduate school enrollment has doubled and quadrupled at many institutions, even though staff, equipment, and budgets have not. This would have created difficulties enough even if other factors had remained unchanged, which they have not.

Need for special instruction is more acute than ever. An increasing percentage of graduate students have had no contact whatever with any foreign language, and many cannot even write an acceptable report in English. They are quite unprepared to "get up" a foreign language on their own, as most could do 25 years ago. I well remember my own graduate Dean who growled at me at registration, "Get that baby stuff out of the way promptly"—and I did so. But it is not baby stuff to the average student today. The usual freshman course in language bores him with its drill on pronunciation and the oral skills, and baffles him with its linguistic terminology and analysis of grammar and syntax. Even the English explanations are foreign to him, and the course seems a strange compound of childish content and highly technical analysis. For his purposes, three or four semesters of such instruction would be necessary. So he gives up, flounders around on his own, and comes insufficiently prepared to take the examination for the language requirement.

No group stands in greater need of special instruction than those students who are now in graduate school, thanks to the G.I. Bill. Through no fault of their own, many of these students have never studied any foreign language, ancient or modern, and a fair number are in need of courses in remedial English.

While considering the problem from the student's point of view, let us not forget that the continuing advance of science and technology is not making it any easier for him to attain full professional competence in his chosen field of specialization. Even if a prescribed curriculum requires so many units of humanistic studies, the budding engineer or scientist is apt to regard such courses as wasted time and do only the minimum, unless the instructor arouses and holds his interest.

Language teachers have not responded to the challenge. In fact many of them have not even become aware that students of science and technology require specialized instruction if they are to obtain maximum benefit from their language courses. Many professors of foreign literature are unqualified and uninterested in the various fields and subfields of science, or in their technical vocabulary. They tend to resent the presence in their classes of young scientists whose lack of previous instruction in languages is a source of difficulty and irritation. Also they tend to be purists and to insist upon the details and niceties of language which mean so much to them, but which are unimportant to students needing a reading knowledge of scientific material. Finally, many language professors resent the whole situation; students and examinations often are an unpaid overtime job thrust upon them, for which they receive little credit or thanks and more often criticism or sometimes even abuse.

Clearly, the situation is false. Professors of foreign literature should not be expected to do a job for which they are not fitted. The graduate school should not ask them to do it as a form of charity. Our graduate students in science and technology deserve the very best of instruction, in foreign language as in other fields. Good teachers with training both in science and in languages can be found, and if given proper rank and salary, they can develop the special courses and needed materials. If we really want these things, we can have them.

[1] Presented at the 119th Meeting of the American Chemical Society, Boston, April, 1951.

[2] DUNKEL, H. B., *J. Higher Education*, 13, 403 (1942).

Professors of science are not guiltless, either. Of the older generation, some, under the pressure of excessive work, have neglected their foreign periodicals, forgotten their foreign languages, and lost their awareness of their value. (It is easy not to notice one's own deficiencies, even of vitamins.) Occasionally one of them even brings personal pressure to bear on the foreign language professor who repeatedly fails a bright but overworked young scientist. Of the younger generation of professors, not a few have gone through the language experience known as "cram, pass, and forget." They have no respect for it, and their attitude is easily caught by their graduate students. Today's graduate students are tomorrow's young professors. The unsatisfactory foreign language situation means that the next generation of scientists will be even less prepared to keep world science in perspective.

Administrative confusion has been a result of the present unsatisfactory situation and also a factor contributing to further worsening. There is general agreement as to what constitutes a satisfactory first course in calculus, or in organic chemistry, or similar courses in other fields; no two schools seem to agree on what the graduate school should have in foreign languages. Vague phrases like "a reading knowledge," "a working knowledge," or even "a dictionary knowledge," can and do mean all things to all people. A recent survey of 12 institutions reveals that the student is variously told to prepare himself by study ranging from "a few weeks" in one institution to "two years" in another. His failure to pass may or may not be recorded on his transcript. His examination may be oral, or written, or a home assignment in extensive translation. A dictionary may be prescribed, or prohibited. The examination may be limited to one hour, or two hours, or it may last an indefinite time. Its material may sometimes be familiar, and sometimes it must be new. In some institutions it must be rather unspecialized, such as general biology; in others it must be highly specialized—not biology, not zoology, not entomology, but the parasitology of crustacea. The examination may be free, and offered several times per term. It may cost the student as much as $25, and be offered only once per term. In some institutions it must be passed in the first year of residence; in others, at any time, even on the eve of Commencement day.

The examination, whatever it is and however administered and graded, is frequently subject to review by the major professor. This division of authority results in friction and inefficiency. In some schools certain of the science and engineering departments have their own examiners and procedures and, of course, their own standards.

The result of all this division of authority and responsibility and of the accompanying differences in opinion has been wavering and uncertain standards. Injustices—real or fancied—have aroused resentment among graduate students and their major professors toward the language department, whose members, as a result, have tended to "play it safe" by giving passing grades to dubious examination papers. After all, nobody protests a passing grade. Yet much yielding to pressure only aggravates the situation by greasing the skids for a further decline in standards. A vicious circle of this sort, once established, requires determined effort to break it up.

The situation being what it is, it is only natural that there should be a wide variety of opinion as to the value of the language requirement for graduate degrees in science and technology. Opinions range from "indispensable tool" to "senseless obstacle." There are those, too, who maintain that however useless as a tool the foreign languages may be in some fields, there is great value in the foreign language experience *per se*, especially in these days, and that the doctorate should not be conferred on any man who is illiterate in all languages except his mother tongue.

There are also those who favor outright abolition of the language requirement for advanced degrees. The scholar whom I quoted earlier writes: "Universal usefulness was the reason for the universal requirement. Yet a large proportion of our students and faculty consider (it) as no longer useful . . . why not do away with the universal requirement and substitute some more acceptable plan?"[3] He concludes that the requirement should be abolished except in those cases where there is clearly a need for it.

This is plausible, but I think it no less dangerous than the reactionary insistence that the present requirement be retained unchanged in all fields, regardless of circumstances. Should each institution or department make its own decision as to the usefulness of a certain language in a certain field? Are all scholars equally informed about the possibility of overseas developments in their field next week or next year? Can American science afford to indulge in isolationism and unpreparedness? Some men of science would answer "yes" but such a decision is surely a serious one, to be taken only after full consideration and consultation among its leaders.

Before we arrive at decisions as to what to do, attention should be given to possibilities of greatly increasing the effectiveness of methods of teaching a reading knowledge of a foreign language to graduate students of science and technology.

Those of us who have developed special language courses for graduates know that a functional reading knowledge of a foreign language can be developed in one semester or less for superior students, and in two semesters for the average. We can make the course interesting and profitable by adapting the content, the methods, and the techniques to the mature interests and special needs of graduate students. By so doing, we can save countless thousands of precious man-hours for graduate research, and we can avoid the frustrations, recriminations, and bitterness which now characterize the situation. And in doing all this, we can restore honest standards. But a few prerequisites are involved.

First of all, we shall need proper tools—effective text-

[3] DUNKEL, H. B., *ibid.*, p. 405.

books and reading material. The grammar books and feeble fiction used in freshman courses are unsuited to the needs and interests of graduate students, and wasteful of their time. There is a great need of special material tailored to their special requirements. That such material can be prepared is attested by J. W. Perry's textbook on "Scientific Russian."[4] This book has been written specifically for those graduate students in science and technology who have never studied Russian but wish to learn to read Russian scientific material. We need more books of this sort—particularly in French and German.

We also need teachers who have a knowledge both of science and language. Such teachers can present languages to our science and engineering graduate students as no one else can.

The fact that something can be done is no cause for easy optimism. How little actually is being done was revealed by the above-mentioned sampling of 12 well-known graduate schools across the country, public and private, technical and general. Of these, only three provided special classes in foreign language for graduate students.

Enough has been said to outline the research problem that confronts us. We need to get facts concerning needs, provide valid definitions, develop needed materials, establish standards, procedures, and policies.

[4] See review, J. CHEM. EDUC., **28**, 345 (1951).

A DEMONSTRATION ON THE CHEMISTRY OF COLOR[1]

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A LECTURE demonstration which included a number of general principles of the chemistry of color proved to be a popular feature of an "Open House" program at Rensselaer Polytechnic Institute. The development of the concepts of the nature of light and color and of the formation and use of colored compounds in an hour program was necessarily kept simple; although conceived for an audience with a background of high-school chemistry and physics the program was enjoyed by some who had less work in science. The demonstration experiments described are not new, but the synthesis of a number of basic concepts, which could be illustrated in striking fashion, afforded an interesting and instructive program.

The sequence of experiments was managed by a number of demonstrators working successively with equipment arranged along a long lecture table. Attention was focused on each experiment in its turn by lighting, while others were being prepared or equipment was being removed. As the experiments were performed, they were explained by a commentator and also by those demonstrating the experiment. The commentator worked from a prepared script which included the basic concepts and modified this extemporaneously to fit the timing of the experiments. Calling on those performing the experiments for explanations and comments, when appropriate, proved to be a very practical way to accommodate minor differences in timing, and gave an effect of spontaneity. It also avoided the possible monotony of a single speaking voice, and allowed the commentator to assume the part of the audience in asking questions.

It will be realized that the experiments on dyeing, in particular, had to be scheduled carefully so that the samples would be ready, in turn, for removal from the dye bath, washing, and exhibition as the script moved to a description of the particular process.

This program was developed in cooperation with a number of students who worked out the details for the most effective demonstration of the experiments and it was presented by a small group of students. It is included here in outline form, with detailed descriptions of the experiments limited to those which are not readily found in commonly available sources. Unless otherwise noted, all materials mentioned are available from laboratory supply companies. The explanations and presentation of the concepts by the commentator are indicated only briefly; the content of this portion of the program must depend on the time available and the background of the audience.

[1] Presented in part at the 119th Meeting of The American Chemical Society, Boston, April, 1951.

DEMONSTRATIONS

(1) Color is the effect of light of certain wave lengths on the eye. Color can be produced by physical structures which separate white light into selected wave lengths and send them along various paths. A prism bends the various wave lengths comprising white light to different degrees and produces a color spectrum.

Fine particles or films may allow certain wave lengths to pass and reflect others. The colors of the rainbow, the blue of the sky, and the red of the setting sun are explained.

(*a*) A spectrum, produced by a good prism, is projected on a screen.

(*b*) Colors produced by Tyndall effect are projected. This is most conveniently illustrated by passing an intense beam of white light through a tank containing dilute sodium thiosulfate to which is gradually added small amounts of very dilute hydrochloric acid to form a monodispersion of colloidal sulfur.[2]

(2) Color produced by colored objects depends on their properties of absorbing light of some wave lengths, and of reflecting or transmitting the light of other wave lengths.

White light is passed through colored filters. Colored objects are examined in white and then in red and blue light.

(3) Many things commonly thought of as colored are colorless materials with small amounts of colored compounds incorporated.

(*a*) Water is colored by a trace of a water-soluble dye, and the separation of this colored solution by distillation is illustrated.

(*b*) The separation of a colored solution by chromatographic adsorption is demonstrated.[3] An adsorption tube is prepared from a glass tube, 13 × 1.7 cm., by placing a pad of cotton over a constriction near one end and pouring in a slurry of adsorbent in distilled water. The adsorbent is a suspension of a commercially available activated alumina adsorbent mixed with 10 per cent Hyflo-Supercel (Johns-Manville) in a solution 0.002 *M* in primary and secondary sodium phosphate (pH 7.04). Two pieces of filter paper placed over the surface of the alumina in the column will prevent channeling. Water is passed through the column, and when the level of the water has fallen to within a few mm. of the top of the alumina, a 2-ml. portion of a 0.5 to 2 per cent solution of mixed dyes is added and allowed to soak into the column. Following this, a 10-ml. portion of water is added to separate ("develop") the dyes. Slight suction may be necessary to accomplish the process in a reasonable time, or tubes can be shown illustrating the various stages of the process. Mixtures of dyes may include auramine 0 and Victoria blue (extremes in rate of adsorption) and any of the following dyes which are intermediate in rate of adsorption: malachite green, crystal violet, safranin 0, and methylene blue.

(4) Color in chemical compounds is a result of absorption of light of selected wave lengths, and may be due to particular structural features. A change in structure may result in a change in the nature of the absorption and a consequent change in color, or a complete loss of it.

(*a*) Dye structures are illustrated by charts, with chromophoric groups indicated.

(*b*) Indicator effects are explained by structure charts and demonstrated with solutions of some of the following dyes: methyl orange, Congo red, methyl violet, and phenolphthalein. The latter two dyes undergo a two-stage color change, methyl violet on acidification and phenolphthalein on addition of alkali. The color changes appear most striking if large beakers of fairly concentrated dye solutions are used, and if these are well illuminated and agitated.

(5) The use of dyes extracted from naturally occurring materials was a very old chemical art. The preparation of synthetic or manufactured dyes, of which the preparation of mauve by Perkin and the synthesis of the valued natural dye, indigo, by von Baeyer are two early examples, was an important step in industrial chemical progress. The synthetic dyes were cheaper, possessed more varied colors and properties, and were purer and more uniform than the natural dyestuffs and eventually displaced them.

The synthesis of indigo by a method[4] which is rapid (although giving poor yields) is demonstrated. The preparation may begin with benzaldehyde or *o*-nitrobenzaldehyde, and the sequence of operations to the filtration of the indigo will be completed in time to use the prepared dye in experiment 8.

(6) Colored compounds are useful dyes for fabrics only if they are retained on the fibers and if they are stable. Fabrics differ markedly in the relative ease with which they can be dyed by a given compound, and, consequently, dyes of special types and methods of application have been developed to meet the various requirements. Not only is the chemical structure of the dye important, but also that of the fiber to be dyed. Chemically, silk and wool are proteins, while cotton, linen, and rayons are composed of cellulose molecules. The amphoteric nature of the proteinoid fibers provides centers of reactivity for dyes possessing acidic and basic groups, but on the other hand, the cellulose fibers are neutral and therefore demonstrate no tendency to react with acidic or basic groups. Thus a substance that dyes silk and wool directly might not affect cotton and vice versa. Synthetic fibers such as Nylon and Saran often cannot be dyed directly and special techniques may be employed to impart color to them.

The difference between fabrics with respect to direct dyeing is illustrated by experiments in dyeing with Congo red, orange II, and Benzo Fast Scarlet.[5] Wool, silk, cotton, and perhaps Nylon, rayon, and acetate rayon[6] may be treated in the dye baths, then rinsed and washed to observe the permanence of the color.[7] While not fast, Congo red is direct for cotton and the indicator effect exhibited by this dye is demonstrated by immersing the dyed samples in dilute acid. Orange II is direct for silk and wool, but does not dye cotton, while Benzo Fast Scarlet, at room temperature, colors cotton and viscose but not silk and wool. At 150°F. the latter dye will color silk more than wool but not as intensely as cotton.[8]

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[2] BHAGAVANTAM, S., "Scattering of Light and Raman Effect," Waltair Andhra University, India, **1940**, pp. 2–3.

[3] Directions included here are those of P. RUGGLI AND P. JENSEN, *Helv. Chim. Acta*, **18**, 624 (1935), including some of the modifications proposed by W. RIEMAN, III, J. CHEM. EDUC., **18**, 131 (1941).

[4] COGHILL, R. D., AND J. M. STURTEVANT, "An Introduction to the Preparation and Identification of Organic Compounds," McGraw-Hill Book Co., Inc., New York, **1936**, p. 114.

[5] Available from the Antara Division, General Dyestuff Corporation, 435 Hudson Street, New York, New York.

[6] Fabric containing strips of wool, viscose, silk, cotton, acetate, and Nylon in a repeating pattern is available from Testfabrics, Inc., 224 W. 35th Street, New York 1, New York.

[7] FIESER, L. F., "Experiments in Organic Chemistry," 2nd ed., D. C. Heath and Co., New York, **1941**, Part I, pp. 257–9.

[8] A recommended dye bath for Benzo Fast Scarlet contains for 15 g. of fabric, 0.15 g. of the dye in a solution containing 6 g. of sodium chloride in 300 cc. of water. The dyeing time, both at room temperature and at 150°F., should be 30 minutes.

(7) Many dyes which cannot be made fast to the fabric in a direct dyeing process can be bound on the fabrics by mordants. These are first precipitated on the fiber, and the dye is then absorbed on the thin coating of mordant to produce an insoluble complex color compound. Dyeing processes using mordants are no longer widely used commercially. Other dyes and methods, some of which are illustrated below, can often be employed more conveniently and economically.

The action of malachite green, direct for silk and wool but not cotton, is demonstrated with mordanted cotton, untreated cotton, silk, and wool. After dyeing, the fabrics are rinsed and washed.

(8) Vat dyeing processes use dyes which are insoluble but which, for application to the fabric, are converted into a soluble, often colorless form. Further chemical reaction, usually an oxidation, then converts the compound to the insoluble colored form. The historic dye indigo is one which is so used.

The indigo prepared earlier in the program is reduced by sodium hydrosulfide or ferrous sulfate solution to the soluble and colorless leuco-indigo. Cotton is boiled in the solution, and upon exposure to the air the oxidized form quickly develops and colors the cloth.

(9) Developed dyes are those in which the last step in the manufacture or synthesis is completed directly on the fiber. There are several such processes. In the use of an ingrain dye or a developed dye, the fabric is first impregnated with a solution of a dye intermediate containing an amino group. After immersing in a diazotizing bath, the fabric is then treated in an acid solution of a second dye intermediate, the developer. The coupling produces the dye directly on the fiber.

Three cotton samples are impregnated with primuline, then placed in a diazotizing bath. After rinsing, one sample of the cloth is transferred to each of three developing solutions. The β-naphthol, resorcinol, and 1-phenyl-3-methyl-5-pyrazolone developers each produce different colors (ref. 7).

(10) "Ice-color dyeing" is accomplished by the reverse processes. The coupling or developing agent is absorbed on the fabric, and this is then passed into the diazonium salt solution for the coupling reaction which produces the dye. The term "ice-color" comes from the fact that the diazonium salt solution must be kept very cold, or it will decompose.

Alkaline solutions of β-naphthol and of 1-phenyl-3-methyl-5-pyrazolone previously prepared are painted in stripes and figures on cotton cloth. The partially dried fabric is then dipped into a cold solution of diazotized *p*-nitroaniline (ref. 7), to develop the dye in the painted figures.

(11) Certain compounds, not dyes in the strict sense of the word, are capable of absorbing ultraviolet light, and then re-emitting visible light of certain wave lengths, thus producing color. The phenomenon is called fluorescence.[9] Fluorescent dyes have found commercial use in recent years. Many of the synthetic soaps and detergents, that are claimed to produce a brighter, whiter wash, contain a colorless, fluorescent organic substance which is adsorbed by the laundered cottons and linens. When exposed to sunlight, which contains ultraviolet light, the laundered item fluoresces to give a brighter, whiter appearance. A substance which produces such an effect is Brightener T, 4,4′(di-*p*-anisoylamino)-stilbene-2,2′-disulfonic acid (ref. 5).

The ultraviolet fluorescence of selected compounds is exhibited. The ultraviolet source must be powerful and must contain little visible light for good effects, and the materials must be relatively pure. The following list is one of increasing order of brilliance of fluorescence: resorcinol, cobaltous acetate, stearic acid, methyl salicylate, phthalic anhydride, salicylic acid, potassium phthalimide, phenanthrene, furfuryl alcohol, phthalimide, anthraquinone, eosin (aqueous), uranium acetate, fluorescein (aqueous), anthracene. The compounds may be irradiated and exhibited in glass tubes, since sufficient ultraviolet light is transmitted.

A sample of cotton is immersed in a 0.5 per cent solution of Brightener T for 20 minutes. After drying somewhat, it and an untreated sample of cotton fabric are irradiated with ultraviolet light. The light source is then turned on the audience and all shirts laundered with a soap or detergent containing a brightener will fluoresce brilliantly.

(12) Fluorescence is an instantaneous process. The emission of light from some materials excited by ultraviolet light persists after the source of excitation has been removed. Such materials are called phosphors and are materials which glow in the dark. Some minerals exhibit striking fluorescent and phosphorescent effects.

The ultraviolet fluorescence and phosphorescence of powdered calcium sulfide, used in luminous paints, and of minerals such as Willemite, fluorite, and Wernerite, are demonstrated.

(13) A few complex organic compounds are capable of emitting visible light when they are oxidized. Only small quantities of these materials are required and there is no heating effect whatsoever in the reaction. The phenomenon is called chemiluminescence, since it is luminescence excited by chemical means. Similar reactions are probably responsible for the light produced by luminous animals and decaying vegetable matter.

A demonstration on a relatively large scale with Luminol[10] provides a spectacular conclusion. Luminol is commercially available, and the use of apparatus of five liter or larger size allows the effects to be clearly visible from all parts of a large, darkened lecture room. The use of small amounts of fluorescent dyes, such as fluorescein and eosin, and of water-soluble dyes, such as malachite green and crystal or methyl violet, in solution with the Luminol, gives striking color effects.

ACKNOWLEDGMENT

The authors wish to thank Dr. David Andrews and Dr. Glenn Shanholtzer of the General Aniline Works, Rensselaer, New York, for their kind criticisms and their suggestions for improving the effectiveness of many of the dyeing process demonstrations.

[9] A recent review article, A. L. POWELL, "Fundamentals of Fluorescence," J. CHEM. EDUC., 24, 423 (1947), provides a useful reference for this and the following section.

[10] HUNTRESS, E. H., L. N. STANLEY, AND A. S. PARKER, "The oxidation of 3-aminophthalhydrazide ("Luminol") as a lecture demonstration of chemiluminescence," J. CHEM. EDUC., 11, 142-5 (1934).

Proceedings of the

PACIFIC SOUTHWEST ASSOCIATION OF CHEMISTRY TEACHERS

MICROCARDS FOR THE CHEMISTRY LIBRARY[1]

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THE chemistry library certainly has its unique problems in this age when the rate of growth of the periodical literature alone taxes its budget and burdens its storage space. But the young library has the additional, herculean tasks of finding back issues to complete journal files and of obtaining standard references which may be out of print or otherwise difficult to procure. In working out solutions for certain of these problems, the librarian at Immaculate Heart College tried microcards, which have recently been perfected and are reasonably priced. Last year the library bought the microcard edition of Beilstein's "Handbuch der organischen Chemie," complete with supplements and indexes, and, since it has proved satisfactory to the chemistry department in this form, I thought microcards might be worth knowing about for others who are interested in building up or maintaining a chemistry library.

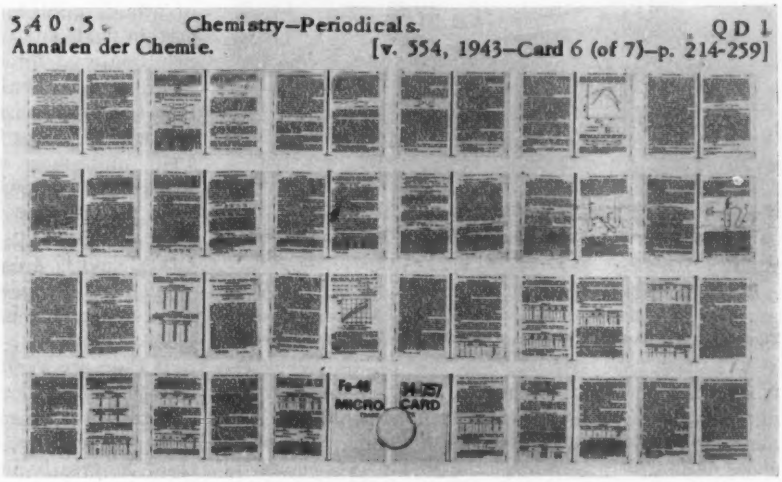


Figure 1. A Microcard, as It Appears to the Eye without the Aid of a Reader

The markings at the top indicate that this is the 6th card of the 7 required to reproduce the 554th volume of the *Annalen*. Pages 214 to 259 are mounted on it in microprint.

Microcards must, first of all, be distinguished from microfilm. Although microcards represent another application of microphotography to the problem of reproduction of printed material, they are different from microfilm in almost every other respect. Microcards are printed on paper, a durable photographic paper, and not on film. They are the size of an ordinary library index card, that is, 7.5 × 12.5 cm. or approximately 3 × 5 in., but each card contains from 40 to 50 pages of printed material. A single page of the original is reduced to a tiny microprint, only one-half inch high, but, when seen on the screen of the reader, it is enlarged to a little more than normal page size. Since the microcards are of standard size, filing cabinets of any desired capacity are readily available and filing or interfiling is easy. The first card of a book or volume is labeled at the top with complete cataloguing information; each of the following cards (Figure 1) has the author, subject heading, and classification heading repeated, with a short title and a notation showing exactly which part of the book appears in microprint on that particular card.

Since the top of each card is clearly labeled, and since separators can be used in the file drawer wherever needed, the location of a particular page reference is as easy and as quick as finding material in a book. For example, in the microcard edition of Beilstein's "Handbuch" the location of the indexes, the volumes, and the supplements can be clearly marked in the file drawer. If, instead, Beilstein were on rolls of microfilm, the location of one page in the text would take more time, since the roll of film would have to be wound through the reader at a rate which would allow the recognition of the specific image being sought. Of course, mechanical selectors, such as signals or frame counters, will undoubtedly come into use, but these will probably increase the cost of readers and also the number of con-

[1] Presented as part of the program sponsored by the PSACT at the Pacific Southwest Regional Meeting of the American Chemical Society, Whittier, California, April 28, 1951.

Courtesy of the Northern Engraving and Manufacturing Company, La Crosse, Wisconsin

Figure 2. The Standard Microcard Reader, Placed on the Market in 1948

trols which the operator has to worry about. Or the librarian could, with sufficient staff help, devise filing methods to facilitate the process of finding page references on film. But with microcards, finding what you want is as simple as locating a reference in a card catalogue. No processing to facilitate reference work is required on the part of the librarian, since the markings on the top of the cards themselves, indicating their full content in readable print, constitute a convenient index.

Microcards are not proposed as a replacement for microfilm, but rather as a valuable supplement. Microfilm is unsurpassed where only a single copy of an article or manuscript is needed. It is firmly established as the accepted medium of such photocopying services as that of the American Chemical Society, which will furnish, through the Department of Agriculture Library, a microfilm copy of any scientific article under 50 pages for $1.10 to its members. On the other hand, microcards will find their greatest usefulness for the chemistry library in the reprinting of valuable reference material and rare volumes of old journals, or in reducing the cost of expensive periodical files. Their sturdiness, low cost, and convenience in use recommend them particularly for frequently consulted reference material.

The story of the development of microcards, from the first publication of the idea in 1944 to actual production in 1948, is an interesting one (*1*, *2*). A proposal for reducing bulky library reference material photographically to microprint was presented by Fremont Rider, the librarian of Wesleyan College, in his book, "The Scholar and the Future of the Research Library." First, as the chairman of the Microcard Committee under the American Library Association, and, finally, as the chairman of the nonprofit Microcard Foundation, Mr. Rider has directed the technical development of his idea. The Northern Engraving and Manufacturing Company of La Crosse, Wisconsin, undertook the development of readers, and the Eastman Kodak Company of Rochester, New York, applied its research facilities to the perfection of microphotographic printing. New cameras, new photographic emulsions, new methods of developing and printing had to be devised in order to make microcards a method of publication on a semi-mass-production scale rather than a method of individual reproduction. At present there are 18 firms or groups publishing microcards, each specializing in certain fields and offering microcard editions of out-of-print material, foreign publications, or expensive collections. So far, only three companies are publishing material in chemistry: the Microcard Foundation itself which has had some offerings in chemistry since 1949, and, more recently, the Technical Microcard Publishing Company and the J. C. Canner Company.

In 1948 the first reader, the Standard Library Model shown in Figure 2, was placed on the market for $195. Other models are now available, some of which are smaller, as compact as a typewriter, but which have good screen lighting and the same magnification power of 24 diameters.

If they are available, microcard editions reduce the cost of journal files and reference material in three important ways: first, by lessening the original purchase price; second, by eliminating the cost of binding; and third, by greatly diminishing the required storage space (*4*).

Storage space is an important consideration, which becomes an acute problem as the library holdings grow. But even the young library must calculate the cost of keeping what it buys. According to one authority (*3*), storage costs in the average library, including amortization of building, shelving, maintenance, heat, light, etc., amount to approximately 20 cents per volume per year. Bound periodicals, however, usually require twice the space and storage costs of books, or approximately 40 cents per year. A library which subscribes to and shelves 500 periodicals each year has an annual increase in its storage cost of $200. If it has back files, averaging 25-year runs, for about one-fifth of its current subscriptions, its periodical storage would then total $1200 for the year, but would mount to $12,200 in a 10-year period. In other words, each bound volume will cost $4 to house for 10 years, and the number of volumes will increase cumulatively.

If the library is to serve the research scholar (*4*), it certainly must keep these periodicals, but the question of how this can be done without sacrificing library service may well arise. It is becoming a commonplace for libraries to add modular constructions to act as warehouses for overflow, usually the material which circulates less frequently. Microcards offer one solution which could prevent such an undesirable storage of re-

search material. For this reason, as they become more available, microcards will undoubtedly come into extensive use as valuable space savers. Instead of having the current periodicals bound at the end of the year, the library could purchase microcard editions for less than the cost of binding, and store them in a small fraction of the space required for the usual volumes. This type of economy is already in practice among certain microfilm users (*3*).

The reduction which microcards effect in the storage space needed for various reference materials is almost spectactular. An ordinary book can be reproduced on from 5 to 10 cards, and 10 cards scarcely occupy one-eighth of an inch in a file drawer. All of Beilstein's "Handbuch," which ordinarily appears on the library shelves in from 53 to 64 bound volumes, can be obtained on 970 microcards, which scarcely fill more than 12 inches in one file drawer. A small filing cabinet, containing 15 of these small drawers, is easily the equivalent of several stack sections in the library.

The purchase price of microcards ranges from 10 to 30 cents per card, depending upon the amount of sale anticipated for the edition. The Microcard Foundation estimates (*1*) that, to sell a microcard for 10 cents, at least 200 copies must be made and sold, in order to distribute the initial cost of publication sufficiently. The average quotations at present are about 20 cents per card, and at this price a 450-page book would cost about $2, which is less than most books cost now. The saving is even more striking when the costs of periodicals or serials are considered. If a scholarly or research journal is under consideration, the subscription price is very apt to be high, and the cost of binding and storing

TABLE 1
Comparison of Estimated Total Costs

	Book Form	*Microcards*
Of a 400-Page Bound Book:		
Purchase Cost	$ 4.00	$2.00
Binding Cost	....	....
Cataloguing Cost	1.25	.20
Storage Cost (10 yr.)	2.00	.10
	$ 7.25	$2.30
Of an 800-Page Volume of a Scholarly Periodical:		
Purchase Cost	8.00	4.00
Binding Cost	2.50	....
Cataloguing Cost	....	....
Storage Cost (10 yr.)	4.00	0.20
	$14.50	$4.20

makes the total even higher. Table 1 shows a comparison between the costs of obtaining, processing, and maintaining the same material in book form and in microcard form. This is a revision, made with the help of our librarian's estimates of current costs, of a similar table in Mr. Rider's Microcard Bulletins.

A comparison of costs, such as those represented in Table 2, persuaded our librarian to adopt microcard

TABLE 2
Comparison of Purchase Prices

Beilstein's "Handbuch der organischen Chemie"	Original edition	$2200
	Lithographic reprint	568
	Microcard edition[a]	194
Annalen der Chemie, Justus Liebig's	Bound run, 1832–1904[b]	3650
	Microcards, 1832–1945	1008
Berichte der deutschen chemischen Gesellschaft	Bound run, 1868–1944[b]	2575
	Microcards, 1868–1944	1168

[a] Quotations from the Microcard Bulletin No. 6, The Microcard Foundation, Middletown, Connecticut, Dec., 1950.
[b] Quotations from the J. C. Canner Spring Catalogue, 1951, for sets of the original journals.

editions for some of the important references we needed. For example, the last time a complete set of the original editions of Beilstein was on the market, it was quoted at $2200, although there was a time when it could be purchased for $1400. An Edward Brothers' lithographic reprint is now $568, while the microcard edition is $194. If a reader had to be obtained just for this one item, the total cost would still be less than two-thirds the cost of the lithographic reprint.

The microcard publications in chemistry are still few in number. All the important items in chemical literature which are already available in microcard editions are listed in Table 3. Some of the items in the Canner catalogue have been omitted because they seemed to be

Courtesy of the Northern Engraving and Manufacturing Company, La Crosse Wisconsin

Figure 3. A Portable Microcard Reader, Model 5

TABLE 3
Microcard Publications in Chemistry (March, 1951)

Publications	*Years*	*Volumes*	*Cards*	*Prices*	*Publishers*
Ann. Chem. Justus Liebig's	1832–1943	554	5043	$1008.80	M.F.
Am. J. Sci.	1818–1949	247	2584	517.00	C.
Beilstein's "Handbuch"	1919, 1929	...	965	194.20	M.F.
Berichte	1868–1945	77	5839	1168.00	M.F.
J. Biol. Chem.	1905–1920	45	(in preparation)		
J. prakt. Chem.	1870–1943	162	(in preparation)		
Kolloid-Z.	1906–1944	107	1126	225.40	M.F.
Monatsh. Chem. (Vienna)	1880–1945	65	(in preparation)		
Naturwissenschaften	1919–1944	32	1143	228.00	C.
Z. anorg. u. allgem. Chem.	1892–1944	200	2548	625.00	T.
Z. physik. Chem.	1887–1944	193	3542	708.60	M.F.

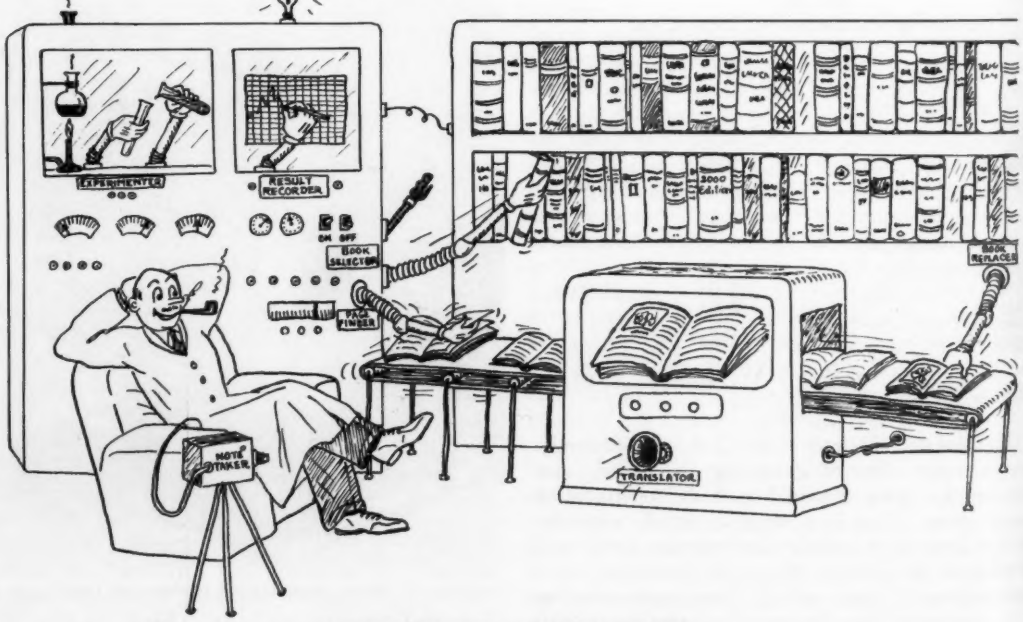
M.F.—Microcard Foundation, Middletown, Connecticut.
C.—J. C. Canner and Company, Inc., 46 Millmont St., Boston 19, Massachusetts.
T.—Technical Microcard Publishing Corporation, 112 Liberty St., New York 6, New York.

isolated volumes rather than full serials. As a dealer in book and periodical collections, Canner is publishing out-of-print volumes to complete particular files, such as the first two volumes of the *Journal of the Association of Official Agricultural Chemists* (1915–16). This journal was started in May, 1915, and then publication was suspended from May, 1917 until November, 1919, so that the first two volumes are missing from many files. These are now available on 22 microcards for $5.80. Also, the first ten volumes of the *Transactions of the American Institute of Chemical Engineers*, for the years 1909 to 1919 during which time this journal was an annual, are available on 98 microcards for $26.

The present list is to be taken as a beginning, we hope, of a growing program for the publication of important serials in chemistry. The publishers plan to make available those references which have hitherto been unobtainable or are prohibitively expensive in the original editions. They would undoubtedly welcome suggestions concerning specific titles which are of interest to a large enough group to warrant production—a group which need not be as large as that required to publish in other forms. An increased recognition of the advantages and potentialities of microcards will encourage more extensive publication in this form.

LITERATURE CITED

(1) The Microcard Bulletin No. 4, The Microcard Foundation, Middleton, Conn., April, 1949.
(2) *Newsweek*, **31**, 92 (May 17, 1948).
(3) "The Problem of Periodical Storage in Libraries," University Microfilms Bulletin, Ann Arbor, Mich., April 1, 1950.
(4) RIDER, FREMONT, *Library Journal*, **75**, 832–6 (1950).



Chemist Doing Library Research—A.D. 2000

Report of the

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS

A NEW PATTERN IN SCIENCE[1]

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CHEMISTS are justly proud of their long tradition of scientific empiricism. I believe they should also be proud of having presented mankind with a new type of scientific knowledge.

First let us illustrate the chemical tradition of empiricism. Here is how Lavoisier defines a chemical element:[2]

> If, by the term *elements*, we mean to express those simple and indivisible atoms of which matter is composed, it is extremely probable we know nothing at all about them; but, if we apply the term *elements*, or *principles of bodies*, to express our idea of the last point which analysis is capable of reaching, we must admit as elements all the substances into which we are capable, by any means, to reduce bodies by decomposition. Not that we are entitled to affirm that these substances we consider as simple may not be compounded of two, or even of a greater number of principles; but, since these principles cannot be separated, or rather since we have not hitherto discovered the means of separating them, they act with regard to us as simple substances, and we ought never to suppose them compounded until experiment and observation have proved them to be so.

This is the orthodox doctrine of scientific empiricism. What we assert today fits the experiments which we have made so far; if tomorrow a new experimental fact contradicts today's theory, that theory will have to go overboard.

For example, today we say that calcium follows potassium in the periodic table. According to the empirical doctrine, if tomorrow we discovered a new element among cyclotron products, having an atomic weight greater than 39.096, but less than 40.08, we should give it its place between potassium and calcium. This is what a good empiricist would say. Is that what you believe yourselves?

Of course not. Your mind rebels at the idea of something coming in between alkali metals and alkaline earths. You believe that the periodic table, although recent, is solid as granite. Let us examine whether your belief is justified. To simplify I shall use only two lines of argument: those of Mendeleev and Rutherford.

Mendeleev first published his periodic table in 1869. He did not begin with arranging the elements in the order of increasing atomic weights, as is sometimes believed. He took a much broader view of the matter, for this is what he said:[3]

> Among [the] measurable properties of the elements, or of their corresponding compounds, are: (*a*) isomorphism, or the analogy of crystalline forms; and, connected with it, the power to form crystalline mixtures which are isomorphous; (*b*) the relation of the volumes of analogous compounds of the elements; (*c*) the composition of their saline compounds; and (*d*) the relation of the atomic weights of the elements... We shall briefly consider these four aspects of the matter, which are exceedingly important for a natural and fruitful grouping of the elements, facilitating, not only a general acquaintance with them, but also their detailed study.

He then built up his table on the basis of these four properties. The table is made up of those famous eight columns and at the bottom of these columns are the formulas for the corresponding "higher saline oxides": R_2O for column I (alkali metals and Cu, Ag, Au), R_2O_2 or RO for column II (alkaline earths and Zn, Cd, Hg), and so forth up to RO_4 for column VIII (Fe, Co, Ni, etc.). On another line below we find RH_4 in column IV (C, etc.), RH_3, RH_2, RH in columns V, VI, and VII. (These lines have disappeared from most periodic tables hanging in our classrooms.) Mendeleev's argument was this: Magnesium is in column II because it forms MgO. Aluminum is in column III because it forms Al_2O_3. A mathematician would have no difficulty inserting many elements R, R', ... between these two, forming the oxides $R_{20}O_{21}$, $R'_{20}O_{22}$, ...let us say. But that is forbidden by property (*b*)! Mendeleev sums up the whole thing in these words: *"The absence of intermediate elements—for instance between magnesium and aluminum...is essentially the most important part of the matter"* (italics his).

[1] Based upon an address presented at the Thirteenth Summer Conference of the NEACT, University of Rhode Island, Kingston, Rhode Island, August 20, 1951.

[2] LAVOISIER, A., "Elements of Chemistry," Henry Regnery Co., Inc., Chicago, 1949, Part I, p. 12.

[3] KNEDLER, J. W., JR., *Editor*, "Masterworks of Science," Doubleday and Co., Inc., New York, 1947, p. 539.

Mendeleev's chemical instinct is apparently what prevented him from saying: between fluorine and sodium, because column 0, that of the inert gases, was not foreseen by Mendeleev. However, note that Mendeleev did not begin by ranging all the elements in one row of increasing atomic weights, and then claiming that such a row was complete. He built up columns of elements of similar chemical behavior, and then said that no new column could be inserted *between these*, because of Gay-Lussac, or Avogadro, or Cannizzaro, as you prefer.[4] Because Mendeleev's views had thus a firm experimental basis, further experiment did not disprove what he actually said, (although it disproved what we sometimes make him say); and column 0 placed itself at the left of column I, the line of the oxide formulas now reading: R (inert gases), R_2O (alkalies) ... etc.

Now let us turn to Rutherford's scattering experiments (1911). They do not merely support Mendeleev's table; they complete it by bringing in a concept which was entirely new in science, and this is the main point of the present paper.

Rutherford bombarded a thin gold foil with alpha particles, found that these were scattered according to some empirical law, and from this law derived the positive electric charge of the gold nucleus which, he assumed, was responsible for the scattering. Next, repeating the experiment with thin foils of other metals, such as silver and platinum, he found the nuclear charges proportional to the atomic numbers of the elements.

The *atomic number* Z is that entirely new type of scientific concept to which I wish to draw your attention. At this stage of the argument it does not mean the number of electrons in the gold or silver atom. The hypothesis of Z electrons was on the contrary introduced shortly afterwards by Rutherford in order to make the atom neutral, while its nucleus carried a charge $+Ze$. No: the atomic number of an element was the *rank* of this element in the linear list of elements of increasing atomic weight, known at the time; thus, for calcium it was 20. No scientific, numerical law among the thousands of those discovered earlier than 1911 (with the notable exception of certain spectroscopic series) ever mentioned the *rank* of something considered as an element in a sequence. Note that if such an empirical law were verified with an experimental error less than $\pm 1/2n$ it would mean that no new element differing from the already known first n elements could ever find place in the sequence.

Rutherford's early measurements of the nuclear charge did not have the precision of better than 1 in 200 necessary to specify the rank of any chemical element in the periodic table. But many investigations during the next 40 years, those with X-ray spectra in particular, have raised the precision much higher. For instance, Moseley's data (1913) placed themselves on two straight lines, but he could make the kink disappear by assuming an element of rank $Z = 43$ (technetium, then unknown), thus raising by one unit the ranks of all elements from ruthenium onwards.[5] Nothing could show more clearly that in the present *list* (not table) of chemical elements we now have an experimentally ordered and complete sequence (complete up to the latest known element, that is). The discovery of any new element, assigned a rank less than 98, would modify the atomic numbers of all the elements to the right of it, and thereby contradict numerical measurements undisputably recorded.

Thus what we may call Lavoisier's "extreme" empirical attitude, according to which any chemical element A, today so called, could tomorrow be decomposed into two *new* elements B and C, an attitude entirely correct in its time and for 120 years later, has now become untenable—not because of any theory or *a priori* argument, but as the outcome of numerical experiments of increasing precision. It is the experimental method itself which after three and a half centuries of progress is presenting us with a statement of a type fundamentally new in science: a statement that tells us that we know for sure all the things of a certain kind that can exist; others, we say, cannot occur.

There are other statements of the same type in the physical sciences. Consider crystals. From the different kinds of symmetry empirically observed in crystals, one can deduce that any specimen must belong to one of 32 crystal classes. This does not tell us why we observe these symmetries and no others, nor how many types of crystals belong to a given class. But in the 1890's, owing to the progress of the mathematical theory of groups, a completely satisfying result was obtained. Working from the single hypothesis that a crystal consists of a certain pattern periodically repeated in all possible directions, three mathematicians, using different methods, obtained the same result. There exist 230 types of periodic space patterns. They of course distribute themselves among the 32 previously known classes.

Two things are particularly remarkable about this result. One is its completeness, the assurance we have that we know *all* the *possible* types of crystals—whereas we do not know yet how many chemical elements there may be. The other is the vast amount of information thus mathematically derived from the single, simple assumption: Crystals are periodic structures. This, which was once a hypothesis, is of course now experimentally established, since otherwise we could have no X-ray diffraction patterns.

Two more examples of a similar character will show what I am getting at. First there is the case of isotopes. Our assumption is that nuclei are made up exclusively of protons (mass 1, charge 1) and neutrons (mass 1, charge 0); this implies that the possible isotopes of a particular element constitute a sequence of equal steps, their nuclei being made up of Z protons and a certain

[4] For an interesting discussion of this point, see LEONARD K. NASH, "The Atomic-Molecular Theory," Harvard University Press, Cambridge, Mass., 1950.

[5] See O. OLDENBERG, "Introduction to Atomic Physics," McGraw-Hill Book Co., Inc., New York, 1949, p. 198.

number of neutrons. Our knowledge of atomic nuclei is still very incomplete, but we are beginning to learn something of what combinations of numbers of protons and neutrons best fit together.

A second example is that of the spectroscopic series. The confusion of lines in the spectrum of an element seemed for decades to defy rational description, and it was a great thrill to spectroscopists when Balmer in 1885 first gave his formula for the emission spectrum of hydrogen. It is well known how Balmer's formula was added to by many other workers, such as Rydberg, Lyman, Paschen, and how we now interpret radiation laws of this type as being due to electrons falling from one energy level down to a lower one, the energies of the different possible levels forming one or several sequences.

It should now be clear what the various laws we have considered have in common. The electronic shells of the chemical elements are built of discrete, identical electrons. A crystal consists of a definite structure repeated at regular intervals. Atomic nuclei are built of identical protons and identical neutrons. The energy levels in Bohr's elementary theory are such that the angular momentum of the revolving electron increases by equal steps. Summing up, experience has led us to the conclusion that these four phenomena —and several others which could be mentioned—are *atomic*. The relevant physical variable does not vary continuously: it can only vary in jumps.

The field of natural science where atomicity was first demonstrated is of course chemistry. The French chemist Proust recognized the law of constant proportions in 1797, and expressed himself as follows:[6]

> We must recognize an invisible hand which holds the balance in the formation of compounds. A compound is a substance to which Nature assigns fixed ratios, it is, in short, a being which Nature never creates other than balance in hand, *pondere et mensura*.

We find here what is typical of every atomic theory, in whatever field: *a principle of exclusion*. Proust's contention was by no means easy to prove, and his controversy with Berthollet is clearly and entertainingly presented by both J. R. Partington and L. K. Nash. Of course if we believe in Dalton's atomic theory (1808), the law of constant proportions, and that of multiple proportions as well, follow as simple corollaries.

In the study of crystals, Abbé R. J. Haüy discovered in 1784 a law of simple ratios connecting the intersections of a crystal face with the edges of an imagined primitive crystal form. This is of course analogous to the chemical law of multiple proportions. Thus were the integers: 1, 2, 3, etc., introduced in chemistry and crystallography. When integers appeared in Balmer's empirical law for the hydrogen spectrum, and then again in the Lyman and Paschen series, it was a settled conclusion that an atom of something or other would have to be brought in to account for this circumstance. The quantity which turned out to be made of atoms, "action," was not popular with physicists, although it figured in analytical dynamics since the eighteenth century, and so had to be rediscovered by Planck and Einstein.

A universe built of atoms, and one made of continuous matter, call for different ways of thinking. Essentially this is because the result of an enumeration must always be a whole number. For instance, Planck has remarked that if there are five apples lying on a table, the ratio of the sides of the table will depend upon the velocity of the observer with regard to the table, but the observer will always see 5 apples, never 4.99, even if he is traveling very fast. Similarly when we determine the molecular weight of an element or of a previously analyzed compound by means of one of Raoult's laws we pay no attention to decimals. We decide for instance that the molecule of iodine is I_2, because it could not be $I_{1.9}$ or $I_{2.1}$, as the experiment may have indicated. This is quite in opposition to our respect for decimals in the measurement of a continuous physical quantity.

A fundamental difference between an atomic universe and a continuous one is then that exact and complete knowledge of a certain limited field may be obtained in the atomic case, but not in the continuous one. This however should not be interpreted in the sense of a final or absolute knowledge. The distinction I mean is the following. We know for sure all of the first 98 chemical elements; this is based on a knowledge of the atom's electrons only; the knowledge of the nucleus, and hence of the isotopes, is a further problem whose solution cannot upset the previous enumeration of the electrons. The 32 crystal classes, forming a complete set, were known long before the 230 space groups which they contain were enumerated. Again, the sequence of spectroscopic lines defined by Balmer's formula corresponds both to observation at a low level of separation and to an analysis which likens the single electron to a small revolving planet; more complicated formulas correspond to fine-structure lines, to the splitting of energy levels, and to the analysis of more complicated atomic models. Thus to the complete knowledge of the properties of a simple model consisting of atoms or particles may later be added the study of another model of the same physical system, having a greater number of parameters or degrees of freedom. But the fact that in an atomic world, our knowledge of a certain subject, say crystal shapes or chemical properties of elements, can be *complete on a certain level*, is the new scientific pattern to which I have wished to draw attention.

It may well be that as a chemist the reader may not think this remark so novel. After all chemists have been dealing with atoms for more than 150 years. Yet I don't remember the point being made in the many presentations of the philosophy of science which have come out in recent years. I believe this is because physical science has dealt with continuous variables from 1600 to 1900, and that many scientists are not yet thoroughly at home in an atomic universe.

[6] PARTINGTON, J. R., "A Short History of Chemistry," Macmillan and Co., London, 1948, p. 153.

To the Editor:

On page 375 of the July, 1951, issue of the JOURNAL OF CHEMICAL EDUCATION, Engelhart exhibits a fine example of one of the most common pitfalls encountered in constructing a so-called "objective" examination. It is stated that each item is to have one correct answer, but only one. In three items listed (187, 188, 189) two items have two possible answers, and one item has no correct matching answer listed.

"Ionize" obviously means to form ions. Therefore if a neutral atom gains electrons, it has formed an ion, in addition to its being reduced. Therefore item 187 may be answered correctly by either B (ionization) or E (reduction).

For the same reason, a neutral atom which loses one or more electrons has formed an ion (ionized) in addition to being oxidized. Therefore item 189 can be correctly answered by two of the listed answers, B (ionization) as well as by D (reduction).

The statement of these two items indicates that the author has employed the very common, but nonetheless fallacious, definition that all oxidations are loss of electrons. Loss of one or more electrons is certainly oxidation, but such a reaction is only one of several means by which a substance may be oxidized. Oxidation may take place by four different means:

(1) Loss of electrons by complete transfer (electrovalent bond formation).

(2) Mutual sharing of electrons (covalent bond formation) in which there is no transfer of electrons.

(3) Covalent bond formation in which there is no complete transfer of electrons, but a *decrease* in electron density of the atom oxidized.

(4) Covalent bond formation in which there is an *increase* in electron density of the atom oxidized.

The reader is referred to C. A. VANDERWERF, J. CHEM. EDUC., **25**, 547 (1948) for a lucid and rational explanation of the role of electrons in redox reactions, and for examples of oxidation by each of the four means listed above. In this excellent article will also be found examples of increase or decrease in electron density, *without* redox.

Item 188 has no correct answer listed in the possible choices. Ions of a salt are not "united" either in water solution or in the dry crystalline solid. Therefore item 188 is not correctly answered by response C, but requires a fifth choice, F, "none of the above," or "nonsense."

Why should a 1951 publication adhere to an 1890 concept of "molecules" of a salt in which ions are "united"?

J. C. HACKNEY

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To the Editor:

The use of ferroxyl gels to demonstrate the corrosion of iron has been given by Meldrum[1] and by Orr and Stafford.[2] The gels may also be used to show that rust is a secondary product of corrosion and that it is formed in the superficial layer of moisture and not directly on the surface of the iron. The gels are left until rust is seen, which is not until a day or so after the Prussian blue precipitate has shown that iron has been passing into solution in the ferrous state. When the gel is split and the nail taken out the nail will be found to be quite clean, the rust remaining in the gel.

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ENGLAND

[1] MELDRUM, W. B., J. CHEM. EDUC., **25**, 254 (1948).
[2] ORR, W. L., AND H. A. STAFFORD, *ibid.*, **27**, 202 (1950).

Recent Books

● PRINCIPLES OF GENERAL CHEMISTRY

Stuart R. Brinkley, **Associate Professor of Chemistry, Yale University. Fourth edition. The Macmillan Co., New York, 1951. x + 703 pp. 178 figs. 46 tables. 16.5 × 24 cm. $5.**

THE fourth edition of this well-known text is very much like the earlier editions in selection and order of material, presentation, and general make-up. The author's statement that "it is intended primarily to provide a thorough background for students in the more advanced sections of the course, who plan to continue their study of this subject" and also for other "qualified students," is apparent to one who critically examines the book. Since it is not intended that this should be used as a text for the average terminal course or in so-called service courses, some descriptive material, such as that relating to industrial and organic chemistry, has been minimized or omitted entirely and the fundamental principles are more thoroughly developed.

The general approach is to base chemical theory on the periodic classification and atomic structure, this section of the text having been considerably augmented in this edition. One difficulty characteristic of this approach, encountered by many teachers who wish to integrate laboratory work with the lectures, is the period of time early in the course while structures are discussed for which no corresponding experiments are available. It is minimized in this text by advancing the kinetic theory and gas

laws to Chapter III and the discussion of oxygen and hydrogen to Chapter IV.

In order to integrate with qualitative analysis during the latter part of the year, all theory is considered in the first two-thirds of the book, followed by several chapters on metals and then four chapters about the most common kinds of salts. The last chapters concern material omitted by many teachers—nuclear reactions and a brief discussion of some typical organic reactions.

A controversial feature of the text is the very early description of alkali metals and halogens in Chapter VII, as typical examples of metals, nonmetals, and their reactions, although the principles of oxidation-reduction are not developed until Chapter XVII, almost 200 pages later.

A section at the back of the book preceding the appendix is devoted to a considerable number of extra problems, no answers being given.

The author has made a clear and understandable presentation of material. Included are a reasonable number of appropriate illustrations, each clearly referred to in the text. The book is printed in clear type on good quality paper and is attractively bound.

FRED C. FREYTAG

University of Wyoming
Laramie, Wyoming

● AMINO ACIDS AND PROTEINS

Edited by *David M. Greenberg*, Professor of Biochemistry, University of California, Berkeley. Charles C. Thomas, Springfield, Illinois, 1951. ix + 950 pp. 79 figs. 76 tables. 16.5 × 26.5 cm. $15.

The editor and 18 contributors have produced in this volume an up-to-date and detailed treatise on many phases of the chemistry and biochemistry of the proteins and their constituent amino acids. The book is a successor to the well-known volume on the same subject edited by C. L. A. Schmidt in 1938. However, the present book devotes more attention to the biochemical aspects of amino acids and proteins as well as recording the advances in protein chemistry during the last 13 years.

The early part consists of chapters concerned with the properties of amino acids (E. E. Howe), methods for their determination (Olcott) and preparation (Archer), including the synthesis of labeled amino acids (Reid and Tolbert). A chapter on the isolation of amino acids is contributed by Dunn and Rockland. Consideration of proteins follows in which classification, purification, and isolation (Fevold), molecular size (Lundgren and Ward), amphoteric properties (Greenberg), criteria of purity (Li) and chemical reactions of proteins (Fraenkel-Conrat) are reviewed in detail. The last 300 pages are devoted to the nutritional (Almquist) and biochemical applications (Greenberg) of proteins and amino acids and their metabolism (Tarver). This part includes a chapter on the chemistry of antibodies by Campbell and Lanni.

It is surprising that no chapter is devoted to nucleoproteins. With the exception of a brief discussion of viruses, nucleoproteins are hardly mentioned. Enzymes are not considered in detail. The editor states (page 723) "... they (enzymes) are too numerous to be considered adequately without unduly lengthening the volume. It is felt that they should be discussed in a separate treatise."

The extent to which detail of analytical or preparatory procedures are included varies considerably from author to author. The use of the Tiselius electrophoresis apparatus, the ultracentrifuge and sedimentation analysis are fully described. Stepwise directions are given for the crystallization of a number of proteins. The techniques for acetylation of amino groups, methylation of carboxyl groups, iodination of phenolic groups also are described in detail. Many readers would like to see the same detail with respect to chromatographic methods that have received so much attention in recent years in the analysis and separation of amino acids. But for such detail he must turn to the references. Indeed one of the outstanding features of this book is the very extensive bibliography at the end of each chapter. This will greatly enhance the value of the volume for the research worker.

It is inevitable that some duplication will occur when a number of authors collaborate, and here one finds the Tiselius apparatus twice described in detail.

The format of the book is excellent and it seems to have been carefully proofread to eliminate typographical errors. The only such noted by this reviewer were on pages 243, 500, and 893.

One has in this volume a valuable summary of our present knowledge of proteins and amino acids, including an immense amount of information on physical and chemical properties as well as methodology and function. It should be of great value to serious students and workers in the vast field of protein chemistry.

F. A. CAJORI

University of Colorado School of Medicine
Denver, Colorado

● AIDS TO ORGANIC CHEMISTRY

Stanley F. Smith. Third edition, revised by _Ian Leslie_, Lecturer in the Department of Chemistry and Biochemistry, St. Thomas' Hospital Medical School, London. Bailliere, Tindall and Cox, London, 1948. viii + 127 pp. 10.5 × 16.5 cm. $1.50.

This booklet can be considered a very abbreviated counterpart of the outline or college series found in most college book stores. It was written to give biochemistry students a review of organic compounds and basic reactions. In 35 chapters all common series are reviewed. Briefly the organization is: (*a*) a few words about the class of compounds, (*b*) some methods of preparation, (*c*) a few properties and/or reactions. The last chapter consisting of five pages, is devoted to "practical tests" giving two to six qualitative tests for seven elements and 26 compounds. Following the index is a four unpaged list of books in the "Students' Aids Series."

Throughout structural formulas are stressed. In spite of some fairly good sections, the briefness of this book casts doubt on its usefulness. In the authors' attempt "to give just the information that is necessary to the understanding of biochemistry," much essential information is eliminated. Catalysts are practically never mentioned, and many reactions, as written, are not correct because qualifying statements are missing. We learn that iodobenzene cannot be made directly from iodine and benzene. This is, of course, correct if concentrated nitric acid is omitted, but we also learn that nitric acid and benzene give nitrobenzene—concentrated sulfuric acid is not mentioned. The reviewer found himself taking issue with statement after statement on page after page. Hence, he feels that since the disadvantages of this book so outweigh the good points it cannot be recommended even as a brush-up text.

ARTHUR FURST

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San Francisco, California

● PRINCIPLES OF PHASE EQUILIBRIA

F. E. W. Wetmore, Associate Professor of Chemistry, University of Toronto, and _D. J. LeRoy_, Professor of Chemistry, University of Toronto. McGraw-Hill Book Co., Inc., New York, 1951. x + 200 pp. 124 figs. 13 tables. 16 × 24 cm. $3.50.

This book is designed as a text for a graduate or advanced undergraduate course in phase-rule studies. The actual systems discussed are well chosen to illustrate the points in question, and the number of systems is kept to the minimum necessary for illustrative purposes. No references to the original literature are given.

Although a thermodynamic derivation of the phase rule and a brief discussion of free-energy-composition curves are given in

appendixes the approach throughout the body of the text is empirical. It is shown at the start that the phase rule can be deduced from laboratory experience alone; that is, that in every case the sum of the number of phases and degrees of freedom is two more than the number of components, where pressure and temperature are the only variables, other than composition, which affect the equilibrium.

After a few of the usual one-component systems are discussed briefly, two-component systems are introduced with a detailed analysis of the system sodium sulfate–water. This system is well suited to such a discussion, since a great variety of phenomena can be illustrated by this one pair of substances. Following this appear discussions of various two-component systems, separated into systems where the composition of only one phase can vary (only one solution), and systems involving two phases of variable composition (two solutions). Here, and throughout the book, considerable attention is paid to the relative amounts of different phases, as determined by the "proportioning rule."

Three-component systems are introduced by a brief discussion of representation with triangular diagrams—equilateral, isosceles right-angled, and irregular—followed by a detailed discussion of the system sodium sulfate–magnesium sulfate–water. Although most of this is devoted to isothermal isobaric conditions, a brief introduction is given to the problem of indicating variable temperature. Various additional types of phenomena encountered in the isothermal isobaric study of three-component systems are next presented, including a very brief treatment of solid solutions. The authors have been successful in illustrating a wide variety of types of phenomena with a comparatively small number of systems.

Many of the phenomena illustrated up to this point in the book might have been encountered (although in less detail and on a more elementary level) by students in beginning physical chemistry courses. The next two chapters, however, are distinctly advanced. The first of these chapters describes a number of types of projections of solid diagrams for three-component systems, necessary where temperature must be indicated as a variable. The second, the last chapter in the book, deals with four-component systems. Neither of these chapters is easy reading, but both are well done and are worth the effort of concentrated study.

Although a careful reading of this book would be worth while for most chemists, it should find its principal value as a text to be studied and discussed by students, with the assistance of a good teacher, in a course in graduate school.

WILLIAM E. CADBURY, JR.

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HAVERFORD, PENNSYLVANIA

● OPTICAL CRYSTALLOGRAPHY

Ernest E. Wahlstrom, **Department of Geology and Mineralogy, University of Colorado. Second edition. John Wiley & Sons, Inc., New York, 1951. 247 pp. 217 figs. 15.5 × 23.5 cm. $4.50.**

THE first edition of this book was noteworthy for its detailed derivations of the various ray and wave surfaces and indicatrices of crystal optics. In the present volume this material is further elucidated by original diagrams in which wave motions or geometrical and optical symmetry are represented in clinographic projection. The construction of such exacting drawings is no mean feat, and they should be of considerable aid in visualizing what is inherently a three-dimensional subject. In this connection, the author would certainly agree with the plaint of all writers on crystals, "if only models could go with the printed page," but he has surpassed other writers in expressing spatial relationships by drawings. Clinographic projection, however, cannot take the place of orthographic drawings, which correspond better with the usual attempts of crystallographers to make observations on "principal views." The latter permit direct scale representation of angles and other data, and also give invaluable drill in visualizations of how exhibited properties change continuously as a crystal is rotated about various axes. For the small crystals (as opposed to thin sections) that chemists deal with, such practice is a useful substitute for universal stage methods, only qualitatively and very briefly discussed by the author.

The designations of refractive indices have been changed in this edition to $n_{\bar{z}}$, n_O, n_X, n_Y, and n_Z, instead of the usual Greek letters, which the authors considers too easily confused with the symbols α, β, and γ commonly used for interaxial angles. (This reviewer does not agree.)

In view of the elaborate treatment of crystal optics, it is surprising to find "plane of polarization" used mostly, when "plane of vibration" (90° to the actual plane of polarization) is meant. The special optics of polarizing microscopes gets hardly as much space as refractometers. Abnormal polarization colors and dispersed birefringence of uniaxial crystals are inadequately discussed.

One would like to find more specific and explanatory directions (in terms of actual stages of manipulation and corresponding observed appearances) for the determination of optical constants and orientation of various specific examples of problematical crystals. This need not be any more elementary than much of the material on lenses and the nature of light, and it would be helpful to those who are attempting to use the book without classroom instruction. In spite of its logical nature, optical crystallography almost demands direct teaching and argument, but chemists who need to use it rarely have such training, and for them the book as it stands would serve best as a supplement to others in the same field.

C. W. MASON

CORNELL UNIVERSITY
ITHACA, NEW YORK

● SOYBEANS AND SOYBEAN PRODUCTS. VOLUME II

Edited by *Klare S. Markley.* Interscience Publishers, Inc., New York, 1951. xvii + 605 (541–1145) pp. 88 figs. 81 tables. 1 plate. 15.5 × 23.5 cm. $11.

THE closing chapter in Volume I of this work is devoted to the mechanical processing of soybeans, including the mechanical removal of the oil. The first chapter of Volume II is devoted to the removal of the oil from soybeans by means of volatile solvents.

The processes are described in detail but deal "primarily with the present-day aspects of the continuous extraction process as applied to soybeans. . . ." Here is described the character of the various solvents used, as well as necessary precautions to be taken because of explosive and fire hazards. Various types of extractors are described and are well illustrated by diagrammatic and photographic reproductions and also by several flow diagrams. That chapter should be as interesting to the chemical engineer as to the chemist.

The chapter on production and utilization of soybean lecithin makes fascinating as well as instructive reading. The author states: "At first no uses could be found for this material.... Within a short space of 20 years thousands of industrial applications have been found." He also gives reference to the use of that material in various types of foods, in pharmaceuticals, and also in solely industrial products. The author gives in minute detail several of his unpublished methods for the rapid determination of phosphorous in lecithin, one a volumetric method using uranyl nitrate solution for the titration; the others are semimicro methods, one colorimetric, the other spectrophotometric.

The chapter on the processing of soybean oil will be of interest to the chemical engineer, particularly that portion pertaining to hydrogenation. The chapter on nutritional value of soybeans and soybean products is of biochemical interest but deals principally with the fat component of the soybean. The chapter on soybean oil by-products describes the chemical structure of soybean sterols as well as the preparation of steroidal hormones. A few pages are devoted to the unusual preparation of soybeans for food

by the housewife. Soybean sauce is an antique product. The author assumes that it has been used by the Chinese for more than 3000 years. In China its production is largely confined to the household, but in the U. S. A. has been transferred almost entirely to the factory. Abstracts of the various methods of manufacturing the product are given, one in great detail. A table of replies from 45 State Agricultural Experiment Stations gives the recommended varieties suitable for growing for household purposes, yet it would appear that only a very slight portion of the soybean crop is raised in the kitchen gardens of the U. S. A. Although this book is definitely not intended to be used as a cookbook by the housewife, yet a number of pages are devoted to home processing of green soybeans. Through the courtesy of the Illinois Agricultural Experiment Station a three-color plate shows three varieties of soybean pods and soybeans, one at the beginning of the edible period and the other two when in prime edible condition with a yellowish green color of the pods. The beans are also shown before and after cooking, which develops the green color. There is a very beautiful monochrome halftone figure showing mung beans and four varieties of soybeans in the dry condition, after soaking and after sprouting. Minute directions are given for carrying out that process, as well as for the preparation of the sprouted beans for the table.

HERMANN C. LYTHGOE

NEWTONVILLE, MASSACHUSETTS

• GENERAL CHEMISTRY FOR COLLEGES

B. Smith Hopkins, **Professor of Inorganic Chemistry, Emeritus, and *John C. Bailar, Jr.,* Professor of Chemistry, University of Illinois. Fourth edition. D. C. Heath and Co., Boston, 1951. x + 694 pp. 290 figs. 75 tables. 1 plate. 17 × 24 cm. $5.50.**

THE fourth edition of this popular textbook is written in the same pleasing narrative style of the previous editions. The book has been enlarged, retaining the same rigorous treatment of concepts. The increase in size is due to the breakdown of chapters appearing in the earlier editions into several new chapters, four of which are: (1) The Periodic System, (2) Measurements, Elements, Compounds, (3) Colloid Chemistry, and (4) Chemical Equations. The early introduction of the periodic system, atomic structure, and valence gives an excellent foundation for later discussions. The latter half of the book, covering principally the metals, is little changed from the third edition, except to bring production figures of compounds up to date.

An attractive feature is the historical references leading to the discovery of the elements, which brings out the human side of chemistry. The inclusion of pictures of common pieces of laboratory apparatus, as well as a good choice of pictures showing industrial processes, is an excellent feature. As with previous editions, it is bascially a "principles" book with many practical applications. The greater emphasis on the long form of the periodic table is a welcome departure from previous editions. Atomic and ionic radii are given in table form with other constants of the elements. Greater emphasis could have been placed on these constants throughout the book. The approach to the solution of problems is quite different from that found in previous editions. Quoting from the preface: "Formulas by which the mathematical problems may be solved have been omitted almost entirely, because it is thought that if the student understands the principles which are involved, he will have no trouble in working simple problems." Unit and factor methods have replaced proportion as such in the solution of chemical problems. An adequate number of examples of problems is given. Boldface type is used in place of italics as in previous editions, to stress words and sentences. Illustrations of apparatus are partially offset on the vertical margins of the pages.

The approach to the study of the elements by starting with oxygen is very nicely developed. The book has eliminated excess "busy-work" in the exercises, particularly as concerns the interconversion of English and metric units, and centigrade and Fahrenheit temperatures. The treatment of silicic acid and the natural silicates is excellent. Some of the diagrams on pages 44 and 45 would have been more meaningful had all the orbits been shown. It would have been an excellent opportunity to differentiate between atomic and ionic size. No mention is made of the use of silver iodide in the production of rain. The inclusion of a diagram in the discussion of ore flotation on page 139 would have helped the student. The equation on page 243 could give the student an erroneous idea concerning the ionization of HCl. The expression "inactive ion pairs," above the equation, is excellent.

The book is free from errors and meets the objectives set up by the authors. It should prove to be a stimulating text to both the student and the teacher.

PAUL R. FREY and C. G. H. JOHNSON

COLORADO A & M COLLEGE
FORT COLLINS, COLORADO

• MATHEMATICS, QUEEN AND SERVANT OF SCIENCE

Eric Temple Bell, **Professor of Mathematics, California Institute of Technology. McGraw-Hill Book Co., Inc., New York, 1951. xx + 437 pp. 36 figs. 14 × 21 cm. $5.**

THIS book accurately describes, in a most entertaining manner, a number of areas of pure and applied mathematics, and names some men who have pioneered them. It is self-contained, and will be much enjoyed by many professional and business people who have never met mathematics beyond the elementary courses, as well as by mathematicians at all levels.

Those who know Professor Bell realize that he tells a very colorful, even salty, story. (Under the pseudonym John Taine he is a successful writer of science fiction.) The author's flair for narrating a yarn is naturally backed up by far more knowledge of mathematics than one expects in a popular expositor. This excess background leaves the author free to be confident, and occasionally even cocky.

In the preface we learn that the book is an integration, revision, and "very considerable amplification" of two of the author's many popular books, "The Queen of the Sciences," 1931, and "The Handmaiden of the Sciences," 1937 (both published by the Williams & Wilkins Company, but out of print). The greater part of the new book is devoted to clearly introducing a number of fields of mathematics and its applications. There are references to some 200 mathematicians from the sixth century B.C. to the present, but admittedly no attempt is made for historical completeness. The material is presented at a leisurely pace, livened by gay verbal illustrations, speculations, frank appraisals, pauses to survey progress, and some flights of fancy (*e. g.*, see page 4 on automatic computers).

The reader who skips the mathematical technicalities will find good reading in the author's refreshing comments about mathematics and its practitioners. For example, in thinking of courses for a sixteen-year-old, he observes (page 11) that "it does seem to some modern minds that Newton and Leibniz were more inspiring leaders than Julius Caesar and his unimaginative lieutenant Titus Labienus." In a general blast at educational testers, we read (page 381) that "mathematicians are not, as a rule, credulous; their clients almost invariably are." The author reveals his perspective by stating (page 311) that "mathematics is but one of several expedients resorted to by scientists, and in many instances one of the less important. Scientists have checks on their work that no mathematician can ever have."

Of the 20 chapters, 13 deal with topics in pure mathematics, namely: spirit of modern mathematics, nature of mathematical truth, postulate systems, our number system, abstract algebra, invariance as the basis of geometry, analytic geometry, abstract geometry and topology, groups, noneuclidean geometry, number theory, infinity, mathematical existence, and consistency. Seven chapters deal with topics in applied mathematics, namely:

practicality of abstract thought, astronomy, continuity in science, uses of calculus, calculus of variations and complex functions, Fourier analysis, probability. The book includes a good index, a list of the mathematicians cited, and 36 line drawings.

On the adverse side, sensitive readers may object to Professor Bell's broad brush and self-confident style. (I didn't.) There are a number of minor typographical slips, and Figure 19 is a poorly drawn hyperbola.

GEORGE E. FORSYTHE

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● SAFETY IN THE CHEMICAL LABORATORY

H. A. J. Pieters, **Head of the Chemical Works Safety Department of the Netherlands State Mines, and** ***J. W. Creyghton,*** **Head of the Medical Department of the Joint Netherlands Coal Mines. Academic Press, Inc., New York, 1951. xii + 258 pp. 58 tables. 50 figs. 14.5 × 22.5 cm. $3.50.**

For the first time in the English language, we now have a book dealing with the problems of safety in the chemical laboratory. Unfortunately, the authors have given the book an industrial hygiene instead of a safety flavor. This approach may enhance the appeal to collegiate levels, but definitely makes it less valuable to industrial chemists where medical and industrial hygiene aspects are usually well controlled. It is likewise noteworthy that the viewpoint is mainly Eurpoean, although considerable reference to the American literature is given in the extensive bibliography.

The major sections deal with toxic substances, their mode of entry into the body, and their analytical determination in the air. Less completely developed are discussions involving glassware, electrical, fire, and explosion hazards, compressed gases, safety instructions and regulations. Although the book contains only a few photographs, it has many excellent sketches showing details of equipment. The numerous tables, mostly dealing with various aspects of toxic substances and recommended first aid, complete the volume.

The book will serve to introduce young chemists to industrial hygiene concepts, and perhaps impress them with some fundamental safety problems. It will not prove as valuable to experienced chemists, however, since its emphasis is on substances which are already well-documented. As a milestone in the literature of chemical accident prevention, the volume deserves a place on the reference shelf of college and industrial chemical libraries, as well as industrial hygiene centers.

HOWARD H. FAWCETT

General Electric Company
Schenectady, New York

● THE ACRIDINES

Adrien Albert, **Professor of Medical Chemistry, The Australian National University, Canberra, and Honorary Lecturer in the Biochemistry Department, University College, London. Edward Arnold & Co., London, 1951. xiii + 381 pp. 32 figs. 99 tables. 19.5 × 25.5 cm. $14.**

The genius of Albert fluoresces with the lively enthusiasm and scholarship of one who has handled acridines in the laboratory. This monograph attempts "to make a critical and orderly summary of the physical, chemical, and biological data scattered through the extensive literature and to draw attention to the inter-relation of certain of these properties." The first eight chapters are concerned with the methods available for synthesis, and these have been classified and graded as to practical utility and scope. The general principles underlying the success or failure of the various reactions have, where know, been brought to the fore. It is hoped that considerations of these fundamentals will save valuable time and material when acridines are being made for the first time. A number of typical preparations have been included, and all of these have been tested by the author and his colleagues.

The middle third of the book is devoted to a presentation of the physical and chemical properties of acridine and its principal derivatives. Considerations of space have prevented every known compound from being mentioned by name, but most acridines containing not more than two types of substituents have been listed. The dependence of properties on electronic distribution has been emphasized and this should help the prediction of the properties of acridines not yet know.

The last third of the book deals with the biological properties and the medical and other uses of acridines.

Less well-known uses of the acridines include the isolation and identification of biological material and the analytical determination of traces of heavy metals. Their outstanding fluorescence properties have made them useful as indicators for the titration of dark-colored solutions under ultraviolet light and as stains in fluorescence microscopy. Acridine figures prominently among the very few chemicals known to have the property of emitting cold light.

The broad interests and pleasing style of the author will appeal to the growing audience of workers engaged in heterocyclic chemistry. Readers of this book will find it a fertile source of ideas for the further development and extension of research problems in this important and interesting subject.

GEORGE HOLMES RICHTER

The Rice Institute
Houston, Texas

● THE CHEMISTRY OF HYDRAZINE

L. F. Audrieth, **Professor of Chemistry, University of Illinois, and** ***Betty Ackerson Ogg,*** **Research Associate, University of Illinois. John Wiley & Sons, Inc., New York, 1951. xii + 244 pp. 14.5 × 22 cm. $5.**

Interest in this compound has greatly increased in recent years since its potential value has become recognized as a fuel component in the propulsion of rockets and other devices. Dr. Audrieth and Miss Ogg have brought together within the compass of less than 250 pages a concise and interesting account of the chemistry of hydrazine, including its relationships to other hydronitrogens, representing, as it does, one of the simpler ammono compounds. The interesting relationships of hydrazine to hydrogen peroxide are also referred to from several points of view.

The formation and the preparation of hydrazine, anhydrous and in solution, are thoroughly reviewed in Chapters 2 and 3; and the following two chapters describe the properties of the anhydrous compound and of its aqueous solutions, respectively.

A comprehensive survey of the thermodynamics of anhydrous hydrazine and its compounds, presented in Chapter 4, constitutes a particularly valuable section of the book.

Chapter 6 deals with the oxidation of hydrazine and its catalytic decomposition, and Chapter 7 covers the quantitative and qualitative analytical aspects of this substance. The hydrazine salts and coordination compounds are discussed in the following two chapters. A consideration of anhydrous hydrazine as a solvent and the hydrazine system of compounds in Chapters 10 and 11, respectively, are especially thought-provoking. The book closes with a short chapter on existing and potential uses of hydrazine and its compounds.

Altogether, it may be said that this book represents a compact, well-arranged, and authoritative account of the chemistry of this valuable substance, the utilization of which is perhaps only beginning to emerge from obscurity. It will be a welcome addition to inorganic chemical literature.

WALTER C. SCHUMB

Massachusetts Institute of Technology
Cambridge, Massachusetts

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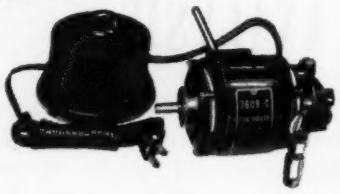

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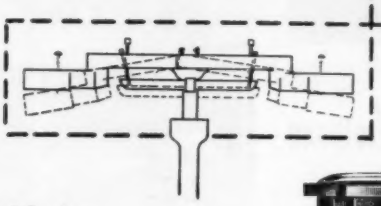

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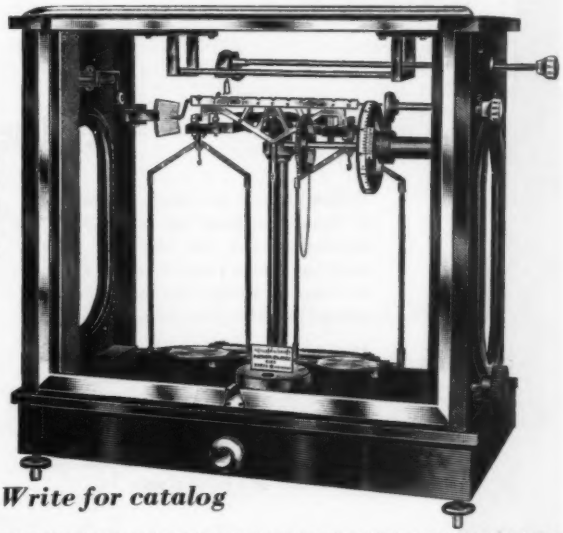

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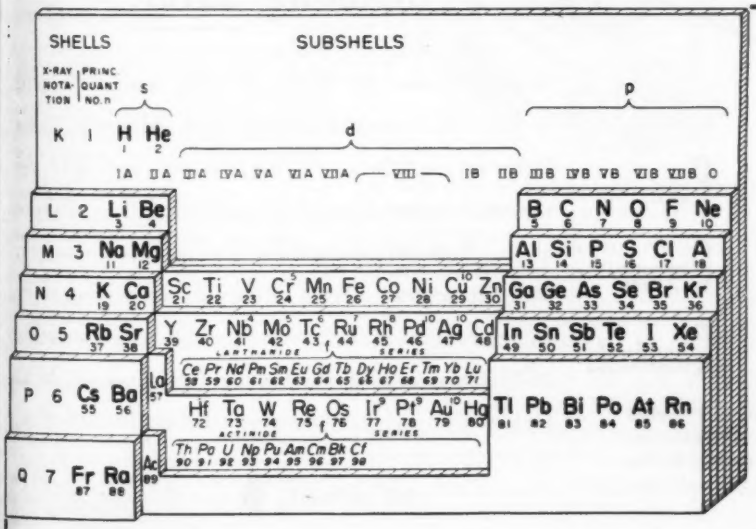
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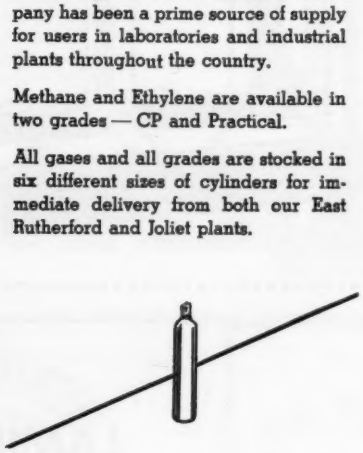

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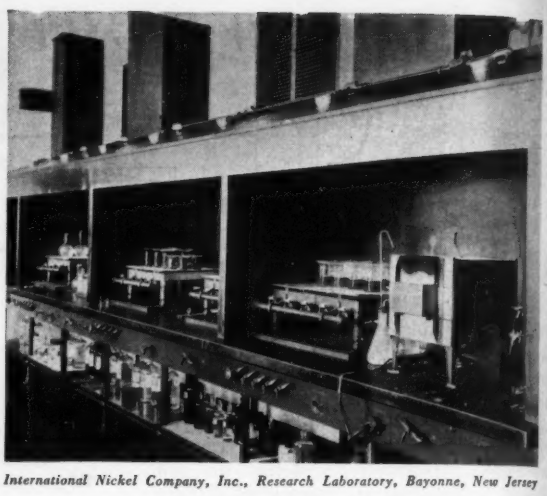

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Out of the Editor's Basket

Teaching Device

There is now available, for teachers and students of general chemistry, a device for teaching the electronic configuration of molecules and the types of covalent bonding. It is called "At-ONS." A set consists of 12 "atoms"—three hydrogens, four oxygens, two nitrogens, and one each of sulfur, carbon, and chlorine. Each "atom" consists of a 2-in. square of transparent sheet plastic, on which is printed the symbol of the element and a number of dots around the edges equal to the number of valence electrons of that element. Each element is printed in a different color. Bonds are denoted by overlapping the squares so that the dots (electrons) taking part in the bond are in the overlapping areas.

These sets are intended to be used by the individual student and are priced accordingly. A large version, with 10-in. squares, suitable for lecture demonstrations, will be available soon. For further information, or to obtain the sets, write: William K. Viertel, 18 Buck St., Canton, New York.

Electroluminescence

A new, revolutionary method of producing light, still in the laboratory stage, apparently transforms electricity directly into light as opposed to light produced by incandescence or the passage of current through a gas or vapor. The light is produced by a phenomenon known as electroluminescence, in which certain materials emit light when placed in a fluctuating electric field. The device comprises a film of phosphor dispersed in a dielectric and placed between two conducting plates. One of the plates is conducting glass so the light produced can emerge. The device is, in effect, a luminous capacitor.

Resin-Treated Paper

A process of treating paper, so that it will be just as strong when wet as when dry, has recently been developed. It involves the addition of malamine-formaldehyde resin to the usual cellulosic papermaking fibers. The resin is cured by heat after the material has been formed into a felt.

Viscosity Packet

The "Brookfield Viscosity Packet," containing information about both Brookfield viscometers and viscosity in general, is available from the Brookfield Engineering Laboratories, Inc., Stoughton, Massachusetts. This packet consists of an eight-page catalogue, data sheet, price lists, "What Users Say" brochure, and list of available article reprints.

Glass Tubing Gage

A precision, micrometer type, glass tubing gage has been announced by E. Machlett & Son, 220 East 23rd Street, New York 10, New York. This gage embodies a micrometer scale with vernier permitting inside measurements of tubing, or any type of circular opening, from 0.01 to 5 mm.

Count Rate Meters

Two new count rate meters are available from the Atomic Instrument Co., 84 Massachusetts Avenue, Cambridge 39, Massachusetts.

Model 410, with an accuracy of 2 per cent, is widely useful in laboratory radioactivity work. In addition to the standard geiger probe input, the instrument is suitable for use with an alpha scintillation probe. Incorporation of a true Schmitt discriminator permits sine wave, square wave, and pulse counting without affecting calibration.

Model 409, accurate to 5 per cent, is ideally suited to applications which are considerably less exacting, such as general safety work, monitoring, or research purposes. Its small size (3.75 × 4.75 × 6.75 in., including chromium-plated steel case)

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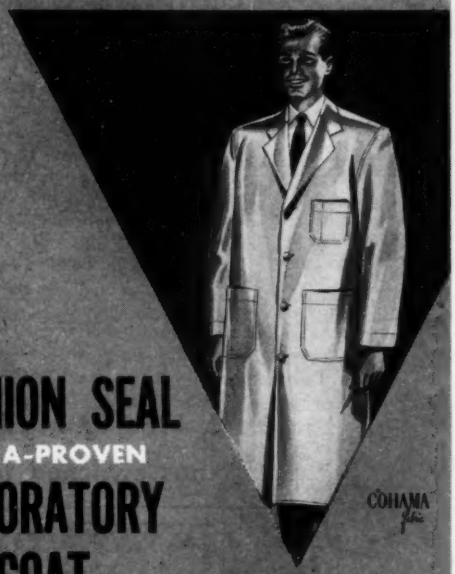

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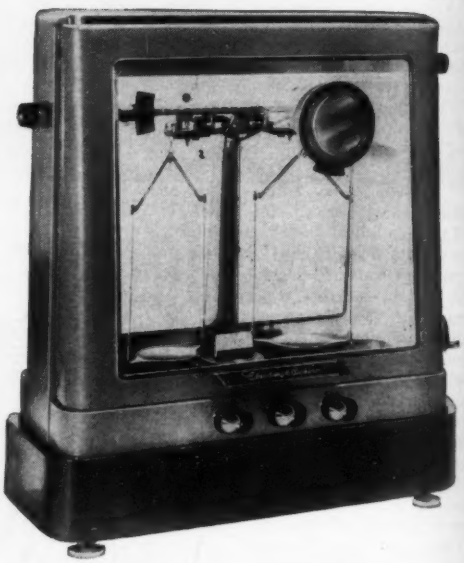

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makes the instrument especially useful where bench space is at a premium.

Further information on both models is contained in a bulletin obtainable from the Atomic Instrument Co.

Catalogue on Isotopes

A new catalogue, "Isotopes," has been put out by the Isotopes Division, U. S. Atomic Energy Commission, Oak Ridge, Tennessee. Besides listing specifications and prices, it gives an extensive coverage of policies, procedures, and services connected with radioisotopes.

The catalogue includes sections on health and safety and a new waste disposal service, a plan for the procurement of radioisotopes, an announcement of a registry of isotope-labeled compounds, information on the export and import of isotopes, and a reprint of the new federal regulations governing radioisotopes distribution.

Miniature Steam Generators

In line with the current trend toward miniaturization in many industrial and laboratory processes, Palo Laboratory Supplies, Inc., New York, has introduced a new miniature automatic steam generator designed to be used with any laboratory apparatus for which steam is required.

The Palo automatic is available in four sizes according to capacity required. The small size has a water capacity of 2 gallons, with a $7^1/_2$-inch × 16-inch boiler, and weighs 140 lb.

The automatic pressure regulator delivers up to 30 lb. Working pressure is 100 lb. per square inch. Starting with a cold boiler, the generator is capable of delivering full steam pressure within 20 minutes.

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Full specifications are available upon request to Palo Laboratory Supplies, Inc., 81-83 Reade Street, New York 7, N. Y.

Experimetrics

A consulting service for the design, analysis, and interpretation of experiments on any scale has been announced by Experimetrics, Inc., Station I, Buffalo 22, New York. Statistical analysis is applied to the experiments, enabling various effects and errors to be estimated numerically. This and similar techniques, such as correlation analysis, furnish a way of reducing unwieldy data to a simple, understandable form. The techniques can be applied to quality control, chemical sampling, and multivariable problems.

A free booklet, "Experimetrics," details the benefits and savings which result from the use of modern statistical methods, and illustrates the techniques involved.

Small Brushes

To aid in cleaning small or awkwardly shaped pieces of apparatus, the Walter Borten Co., Furnace Dock Road, Peekskill, New York, has made available very small brushes which can be adapted or modified for a particular requirement. Various kinds, lengths, and diameters of wire and bristles are used. The manufacturers will submit brushes designed to meet specified needs.

Catalogue of Motion Pictures

A revised 24-page motion picture catalogue, describing 18 sound motion pictures for schools, has been announced by the School Service Department of the Westinghouse Electric Corporation.

The films described in the catalogue are loaned free except for transportation costs and have been chosen for their suitability for schoolroom use. They cover subjects in the fields of science, home economics, industrial arts, social science, agriculture, and salesmanship. Many are recommended for general assembly. The catalogue also describes supplementary material available as teaching aids for use with the films. For convenience in ordering the films and supplementary material, order blanks are included with each catalogue.

Teachers can obtain copies of the revised catalogue (B-5409) by writing to the School Service Department, Westinghouse Electric Corporation, 306 Fourth Avenue, Box 1017, Pittsburgh 30, Pa.

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Some of the outstanding articles from the Summer '51 issue are listed below:

HARVARD METEOR CAMERA
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ULTRAVIOLET MICROSPECTROSCOPY
Article by A. W. Pollister

INFRARED BOOSTS PENICILLIN PRODUCTION
Product Control Story

Among the subjects in our Fall '51 issue:

FLAME PHOTOMETER AIDS ORANGE PRODUCTION
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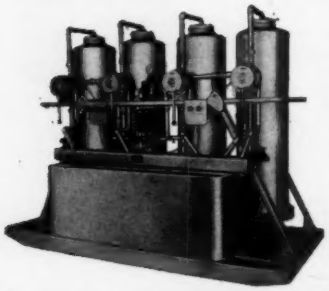

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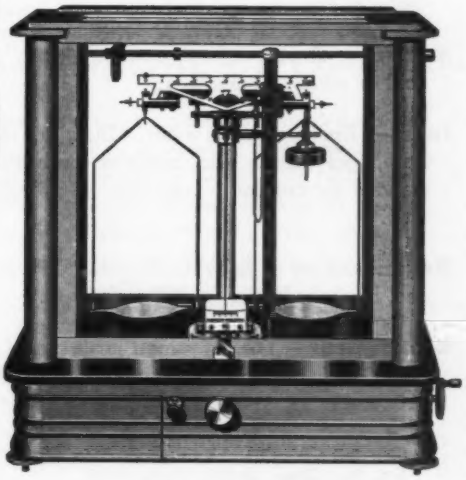

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References

(1) Ind. Eng. Chem. 25-653 (June, 1933)

(2) Ind. Eng. Chem. 25-1112 (Oct., 1933)

(3) National Bureau of Standards Journal of Research 12-241 (Feb. 1934, R.P. No. 649)

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The Life of Ira Remsen

By Frederick H. Getman

Remsen

". . . a pleasantly written and interesting biography of a great chemist."

Remsen's greatest fame was the discovery of the synthesis of saccharin which was the result of the joint work of Fahlberg, a German student working with Remsen and of Remsen himself. The way in which Fahlberg succeeded in concentrating all the fame on himself and in which he commercialized this invention is told in detail and it deserves to be told. It was an unpleasant affair that caused Remsen much trouble even in quarters where he had not expected it, as subsequent difficulties with the editor of the *Journal of the Society of Chemical Industry* proved.

Remsen's work as a university president and a public servant constitute another example of the vicissitudes of an honest scientist in local and national politics and they are well told. Seeing the elaborate bibliography of Remsen's publications appended to this book we have the feeling, even after the pleasant hours spent in reading it, that most has not been made of the evolution of Remsen's practical and theoretical work as seen against the background of American organic chemistry of those days. Should anyone later attempt to write this more elaborate biography he will surely find this book a handy collection of facts to start from.

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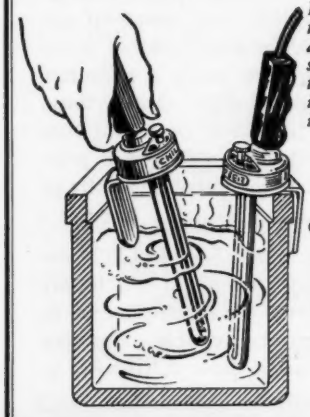

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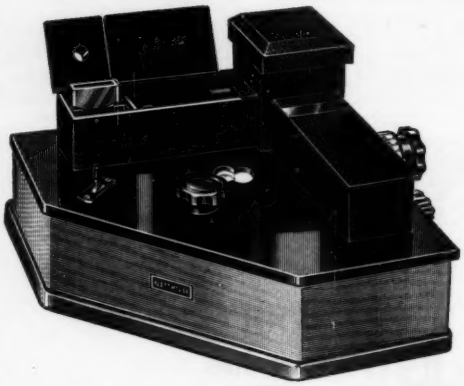

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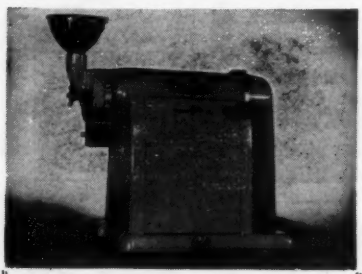

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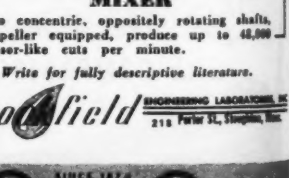

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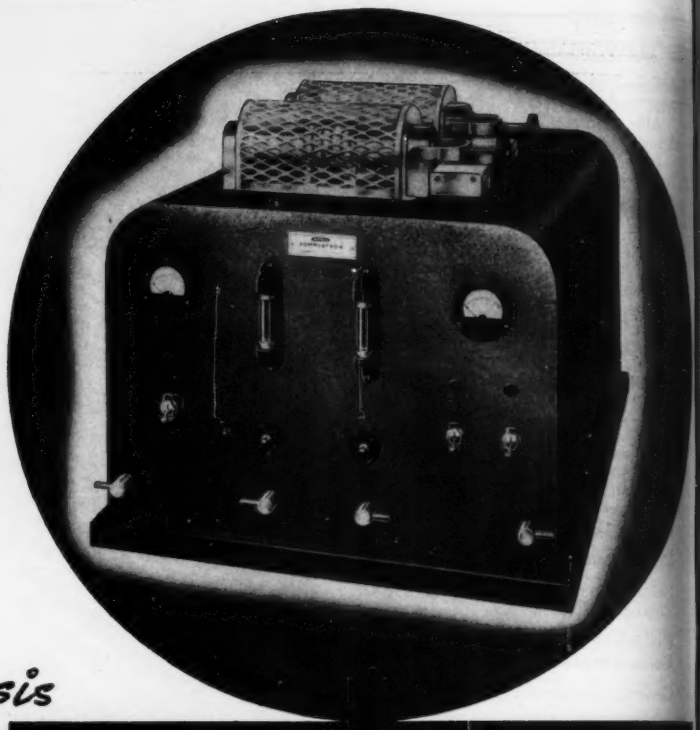

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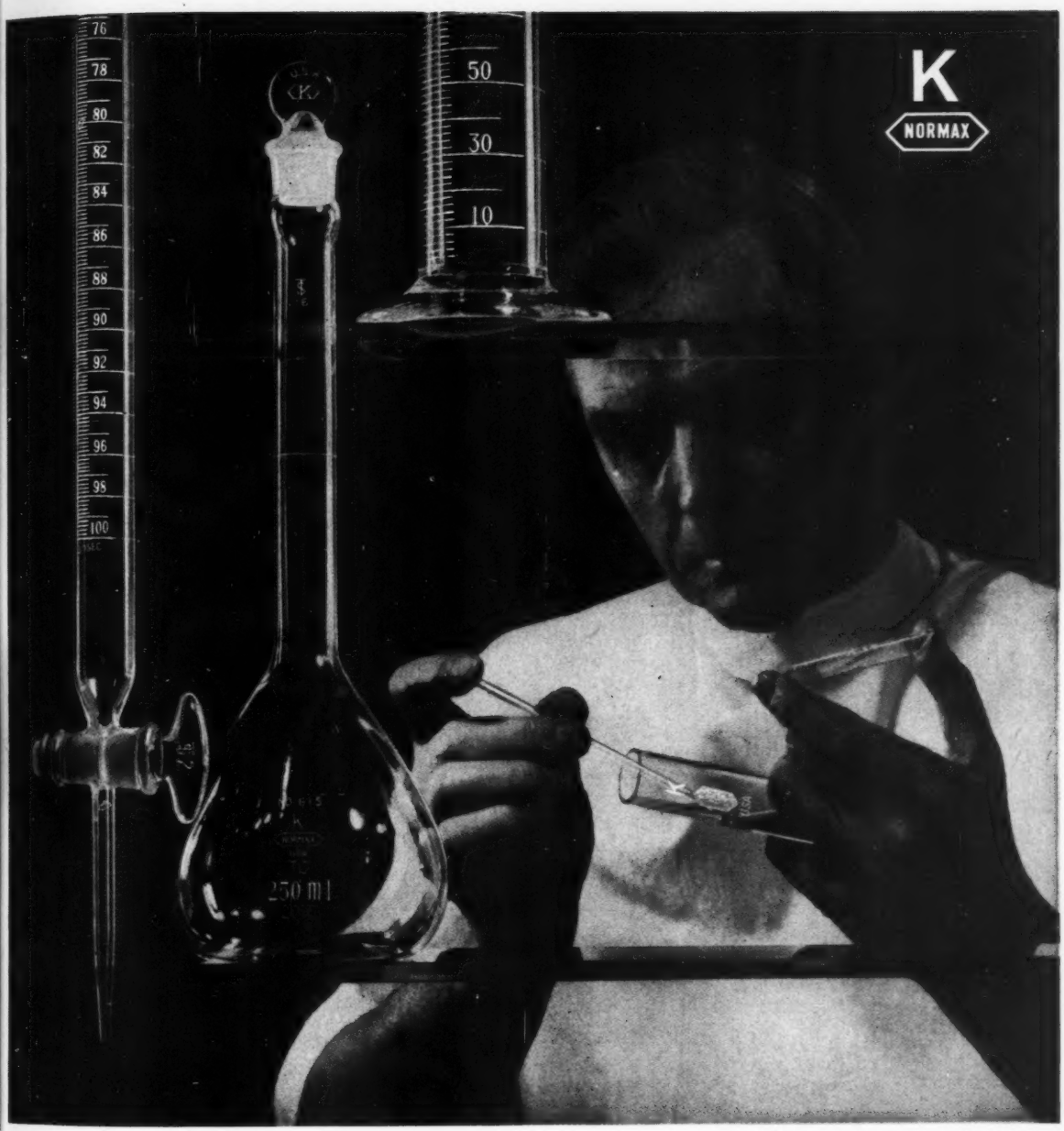

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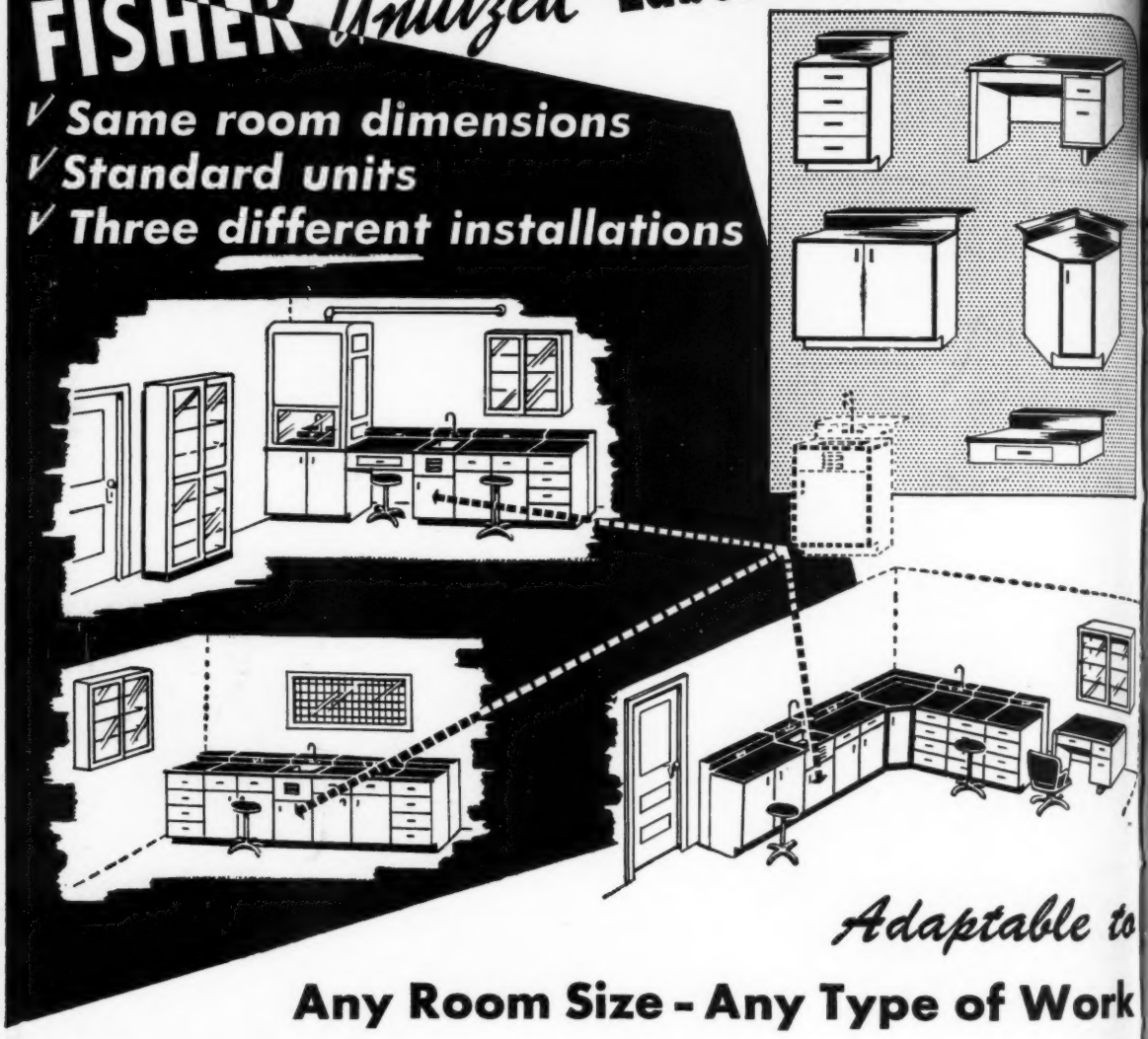

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